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BENIGN TUMOR FORMATIONS OF THE LARGE BOWEL

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A decade ago, I was privileged to discuss before this Congress, the common benign tumors of the rectum and colon—emphasizing the ployp, the fibroma, the lipoma and the eleoma, a pseudotumor produced by the introduction of oil under the bowel mucosa. At that time attention was called to the curious and constant diagnostic relationship between all the colonic neoplasms, the thread that binds the group together being the ever present specter of malignancy.

Those of us who accept the responsibility of determining the nature of organic lesions of the colon are obligated in every instance to rule out the presence of cancer or, this being impossible through some mimicry by benign disease, to plan the surgical procedure so as to protect the interest of the patient at all events.

At this time seven other tumors and tumefacient diseases partial to the colon which frequently or infrequently cloud the diagnostic picture of the large gut will be enumerated and described briefly.

Regional Ileitis, for example, is a granulomatous proliferative process of chronic inflammatory nature which, by preference, begins at the ileocecal valve and extends upward along the terminal part of the ileum; direct extension to the cecum and ascending colon occurs frequently, which is in part responsible for the suggestion that "regional enteritis" is the proper name for the lesion. Its symptom complex is characterized by pain in the right lower quadrant of the abdomen, diarrhea, fever, occasional obstructive phenomena and the formation of fistulous tracts to

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nearby viscera or to the abdominal wall. Young men are commonly afflicted.

In the acute form the bowel is red and swollen, with adherence to the omentum and adjacent peritoneum and is associated with soft, enlarged mesenteric lymph nodes. When the chronic phase is reached, the patient has lost appetite and weight and has a chronic incomplete obstruction and not infrequently a palpable mass which consists of gray, soggy, edematous, adherent terminal ileum and cecum. This mass may prolapse into the pelvis.

The treatment is surgical and consists in radical removal of the portion of the bowel involved. It has been suggested that this may be done in one stage if, as is usually the case, the abdomen has been entered recently and in the process of appendectomy a protective vaccination accomplished.

Ameboma: In localities in which amebiasis is endemic, this disease may produce bowel lesions simulating tumor. Because extirpation is seldom indicated, the differentiation is even more important.

The chief responsibility of the intestinal surgeon in connection with amebiasis is not the performance of surgical procedures for the correction of complications due to this protozoa, but instead the acquisition of sufficient information concerning the progress of the disease and its protean manifestations to suspect its presence where atypical ulceration, tumefaction or constriction of the bowel is encountered.

The constant mental awareness essential to including amebiasis in the differential diagnosis of such lesions is unquestionably more difficult to attain in communities where the disease is not generally regarded as endemic. North Texas is such an area—but a survey of those employed in the kitchens and restaurants of Dallas, conducted a few years ago, revealed that over 5 per cent of those Caucasians, Mexicans and Negroes investigated harbored the infection. It is to be expected that new and additional strains of the Endamoeba Histolytica will appear in this country as the result of the return of soldiers from tropic battlefields, for no amount of vigilance on the part of our medical officers can overcome the natural tendency of the infection to persist, encyst and recur. Moreover, the Chicago epidemic demonstrated that a new and virulent strain has a tendency to produce bizarre and puzzling complications; let us hope that the record will not again show an increase in mortality from injudicious surgery.

Certain intestinal complications, including perforation, abscess formation and stricture, may demand surgical intervention, but

anti-amebic therapy should precede and accompany any such mechanical measures which of course implies recognition of the causative factor. The illustration (fig. 1) represents an ame-

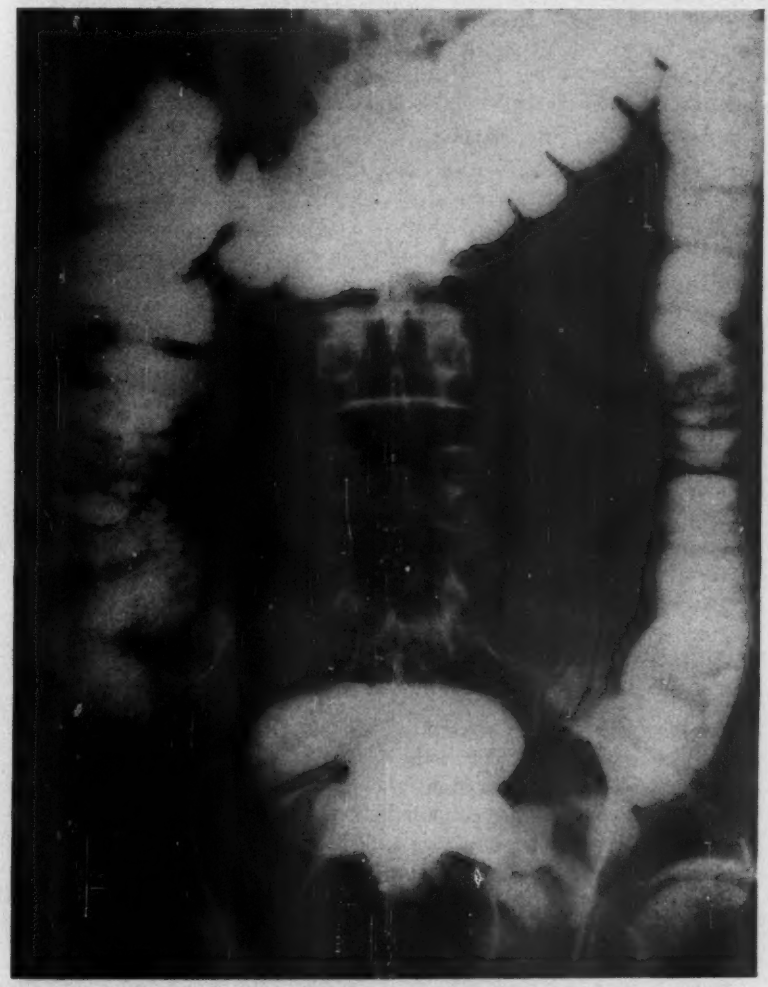

Fig. 1. Ameboma of right colon.

boma of the entire right colon in a young man with no previous history of dysentery. The tumefaction was palpable and painful and, when observed during laparotomy, was firm and dull red in color. The treatment is, of course, not surgical.

Non-Specific Granuloma: Objection has been raised to separating regional enteritis, a granulomatous, progressively extending and migrating disease involving the bowel wall, from a rarer group of massive, localized, nonspecific neoplasms which occur in the colon and in other portions of the bowel, but Crohn[1] believes that, although the etiologic agent may well be the same, the gross appearance, anatomic location and dissimilar method of growth and extension warrant their separate consideration.

Moynihan[2] in 1906 described six inflammatory tumors of the large intestine which, before exploration, he confidently expected to be cancers, and differentiated these tumors from tuberculosis. In 1908 Mayo-Robson[2] described 11 such cases, some found in the cecum and large intestine, and later Braun[2] added 3 instances of granulomas of the splenic flexure to the previous experience.

Localized nonspecific granulomas of this character, while of unknown origin and while presenting a microscopic picture somewhat resembling regional enteritis, do not cause diarrhea, stricture and fistulous tracts; they tend to increase in size while remaining at one area on the bowel. I encountered a neoplasm of this type recently in a man aged 74 who for one year had noticed constipation, flatulence, indigestion and cramping in the lower abdomen and who, on examination, was found to be anemic and underweight and to have a firm palpable tumor in the right lower quadrant of the abdomen. When the right colon was removed by the Lahey technic, the tumor so resembled an adenocarcinoma, because of its texture, indurated surface and absence of change in the adjacent bowel that the pathologist's report (fig. 2) was the first intimation that the lesion was benign.

Simple Ulcer of the Cecum:[3] This was first described a century ago by Cruveilhier. While he stated that the condition could occur anywhere in the colon, the great majority of cases which have been reported have been in the cecum, on the mesial side near the valve. The cause is unknown; the diagnosis in no instance has been before celiotomy or autopsy. While few cases have been reported in the literature, it is probable that numerous unreported or unrecognized instances of this disease have occurred.

Early collected reports of nonspecific colonic ulcers attempted the correlation of lesions from all portions of the bowel, including instances of multiple ulceration. Because the cecal ulcers suggest a definite clinical entity more clearly than lesions in the left colon and because the latter may presumably have been the result of ulcerative colitis and other disease processes partial to the left colon, the pathologist now tends to segregate the single, non-

specific, penetrating ulcer of the right colon as more nearly answering the essential criteria for a pathologic entity.

This condition is encountered in both sexes at varying ages and may first present itself in an acute formulating stage with im-

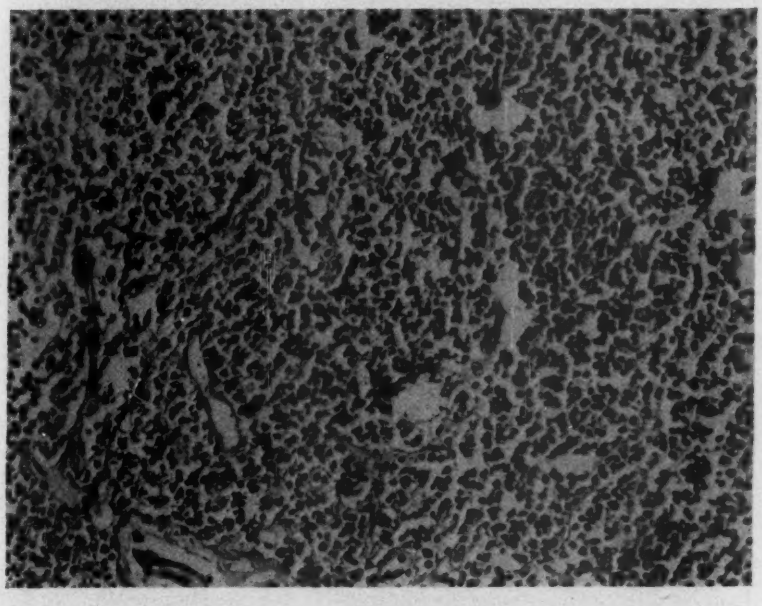

Fig. 2. Photomicrograph of nonspecific granuloma of cecum.

pending or accomplished perforation. In this stage the symptoms mimic those of acute appendicitis and this is the usual preoperative diagnosis. Closure of the ulcer is the satisfactory treatment. In the chronic stage, resection of the right colon is indicated. The preoperative diagnosis is usually cancer.

Hypertrophic Tuberculosis: This condition of the intestine, restricted chiefly to the cecum, was first described by Henri Hartman of Paris in 1891. It is frequently a primary lesion. The tissue change is characterized by cellular infiltration and excessive fibrosis, with consequent thickening of the wall and constriction of the lumen. The symptoms are local tenderness and pain, occasional bleeding, flatulence and indigestion. If the disease involves a limited area of the large bowel, complete resection is indicated.

Endometriosis may infiltrate the upper rectum and the sigmoid, produce an annular lesion and simulate adenocarcinoma or sar-

coma. The usual history in such cases describes a female of 30 to 45 years of age who has not recently given birth to a child and whose chief complaints are gradually increasing constipation and a dull pain in the left lower quadrant—increased during the menstrual period. Involvement through the mucosa is absent or late and bleeding consequently absent. Such invasion of the upper rectum or the sigmoid by endometrial bits of mullerian mucosa deposited on the serosa by retrograde menstruation may present a serious diagnostic problem. Proctoscopic examination is usually negative because the mucosa is not involved. Twelve years ago, however, I resected an annular constricting tumor of the upper recto-sigmoid in a bowel showing definite evidence of mucosal ulceration when visualized. Since the lesion was obstructive and since the bowel was anastomosed, there was no chagrin when the subsequent pathologic diagnosis of endometriosis was recorded.

More recently we encountered an annular, constricting and dimpled lesion in a woman of 44 years. The presence of diverticulosis, revealed by roentgenray (fig. 3) further complicated the diagnostic picture. The lesion was removed and an end-to-end anastomosis done, the clinical diagnosis being adenocarcinoma. Here again the microscopic section demonstrated that the tumor was endometrial.

It is agreed that the major manifestations of *diverticulitis* occur in the sigmoid regardless of the extent of the preceding diverticulosis. This localization is apparently due to the smaller bowel caliber, the presence of firmer fecal masses more likely to produce fecaliths in the pockets and the tendency of the bolus to be retained for long periods above the rectosigmoid canal. For this reason, extirpation of involved segments in this area gives promise of permanent relief from serious complications.[4]

We know that bleeding from the bowel may be produced by both diverticulitis and carcinoma and that diverticulosis may coexist with malignant tumors. The absolute differentiation between the two conditions is not always possible.

The regime recommended in the past which carried with it a tremendously prolonged period of morbidity has been so unsatisfactory that it has been urged that medical means should be resorted to even more assiduously. This policy would, of course, subject the patient to even greater opportunity for serious and perhaps fatal complications. Compared to many other abdominal conditions of a surgical nature diverticulitis is still sufficiently novel to make it probable that the optimum method of management has not even now been arrived at but it is evident that our

Fig. 3. Endometriosis of sigmoid with coincident diverticulosis; insert—photomicrograph of endometrial invasion of bowel wall.

methods during the past quarter of a century have not been ideal. The management of diverticulitis is one of the most difficult problems in bowel surgery, more difficult than that of malignant lesions. Even though diverticulitis does not cause malignant degeneration in the bowel, these two conditions may be coexistent and their differentiation is often impossible. A method of management which imposes a waiting period of nine to twelve months following the construction of a colostomy for diverticulitis before deciding whether resection is indicated places an unwarranted burden upon the patient and leaves the question of a possible additional lesion unsolved.

With all the information afforded by proctoscopic examination, roentgenogram and laboratory findings previous to celiotomy, the surgeon should be competent to determine, with the added

benefit of minimum exploration of the tumor, whether or not resection is indicated. If resection is to be done for diverticulitis, the condition of each patient following the colostomy should determine the length of the interval before the lesion is removed.

Comment: It is often difficult to outline, before the abdomen is explored, a clear-cut differentiation between the common adenocarcinoma of the colon and these other tumors and inflammatory lesions, because of such coincident factors as mass, similar roentgenographic appearance and chronicity. It is quite fortunate, then, that in practically all of the latter, surgical intervention is indicated. If the patient has previously had the benefit of the essential and comprehensive protective and rehabilitative measures now regarded as adequate—including thorough decompression of the bowel and destruction of its coliform bacteria by appropriate sulfa therapy—any discrepancy in the preoperative diagnosis may be corrected and the proper procedure instituted at the time of surgery.

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SCALP LESIONS CAUSING HEADACHE SURGICAL TREATMENT

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The scalp area is richly supplied with sensory nerves. Injury and other types of pathologic changes involving these nerves may produce chronic pain syndromes which are grouped under the common complaint of headache. In some instances, the character of the pain is sharp, intermittent, and radiating to a degree that is recognized as neuralgic. To many patients, on the other hand, pain in the cephalic region is a headache and nothing else. It is to this latter type that particular attention is called.

It is recognized that cutaneous nerve fibers manifest a considerable tendency to regenerate after division. Thus recovery of somatic[1] and of sympathetic[2] nerve function occurs even in skin transplants. When regenerating nerve fibers become involved in areas of chronic inflammation or of cicatrization, painful scars may result,[3,4]. Such anomalies of regeneration and other pathologic changes in superficial cutaneous nerves may give rise to headache, when the scalp area is involved.[5]

The nerves of the scalp are particularly vulnerable to injury. There is a comparatively thin layer of tissue from skin surface to bone, so that the intervening nerves are likely to be damaged in various types of trauma. While areas of injury in the scalp are not generally subject to much stress and strain of muscular movements, they may be pressed upon by constricting headgear, of which more will be said later. The head is a particularly sensitive area. The patient's attention and concern are apt to be greater from discomfort in this region than in other parts of the body.

The head is a frequent target of external trauma. In the so-called sport of boxing, the primary offensive tactics are directed at the opponent's cranium, while the defensive seeks to avoid such contact or to parry the blow with an interposed shoulder girdle. Defensive failure is epitomized in the famous remark "I forgot to duck." In less genteel circles, the instruments of deliberate trauma include brass knuckles, hammers, hand-billies, bricks, and lead pipes. In accidental injuries, moreover, the head is likely to be to the forefront. Sudden arrest of rapid spatial

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velocity, as in automobile accidents and contact with objects moving in space, either falling by gravity or propelled by explosive power in military activity, frequently exert their primary effect on the scalp area. Man is often accused of sticking his neck out; but the head is running interference and bears the brunt.

Headache is a universal complaint with many causes. Probably only a fraction of one per cent of chronic headaches can be attributed to lesions of scalp nerves. Yet, in preparing this discussion, I found 34 such cases referred for consultation to my office during the past two years. This does not include other cases seen in routine hospital practice.

The pathologic aspects of lesions of scalp nerves have been of particular interest. Scars following lacerations have become the focus of headache. On the other hand, scars after elective operations, usually planned to avoid major blood vessels as well as nerves, have not resulted in painful scars. Examination of cases of persisting headache after laceration of the scalp is directed to eliciting local tenderness especially to firm pressure. Not infrequently, pressure at a particular point on the scar produces not only local pain but the headache which is the patient's chief complaint. The indication for treatment is clear; excision of the area of tenderness. By appropriate silver impregnation methods, microscopic sections have shown nerve fibers either compressed by hyperplastic scar tissue or forming actual microscopic neuromas. Lacerations in a position to involve larger nerve trunks primarily and those elsewhere with excessive scar from delayed healing have been more prone to persisting pain and headache. Recurrence of headache after excision of painful scars on the scalp has been unusual.

Severe local contusion of the scalp has resulted in local headache in a number of instances. However, unless a compensation neurosis is present, the pain tends to disappear within a few months. Local nerve blocks are useful in such cases.

Tumors may occasionally involve scalp nerves and produce headache. Sebaceous cysts are rarely painful. Ivory osteoma has been observed to cause headache and to be relieved by operation. It has been difficult to evaluate the relative role of pressure on scalp nerves versus simple stretching of the periosteum in such cases. In one instance, a migraine of many years' duration was found to be related to a fibrolipoma enveloping the greater occipital nerve. Recurrence of headache beginning five months after operation is presumably related to nerve regeneration into the scar. Headache from primary carcinoma in areas involving nerves to the scalp, notably about the ear, is a common observation.

Palpable tender nodules especially in the occipital region are associated with headache not infrequently. Pathologic study of such nodules have shown some to be simply lymphadenitis. In other cases, one finds only dense fibrous tissue in the subcutaneous fat or attached to the deep fascia. In this connection, it is well to recall that the occipital region of the scalp is supplied by nerves from the second and third cervical nerve roots. Accordingly, cervical arthritis, peri-articular changes such as fibrositis and myositis, and purely postural strain can give rise to an ache referred entirely to the occipital region of the scalp.

Headache characterized by local nerve tenderness without demonstrable pathologic cause remains an enigma. Microscopic study of such nerves has yielded no information of value.

The treatment of headache resulting from injury to nerves of the scalp depends upon a recognition of the pathologic physiology. Expectant observation in most instances is indicated for some months after injury, since spontaneous recovery is common. Inflammatory changes of microscopic dimensions may finally subside. Regenerating nerve fibers in an area of injury may become less irritable by acquiring their sheaths of myelin or Schwann cells. Scar tissue ceases to contract after a time with adjustment of nerve fibers to their new situation.

Nerve blocks proximal to points of tenderness have proved useful in many cases regardless of the local pathology. Procaine injections may confirm one's impression from physical examination that the origo mali is in a certain scalp nerve. More than that, one or more injections of procaine may result in a prolonged relief from headache. The detailed studies by Livingston[6] on interruption of the pain mechanism is thought-provoking. Regardless of the occasional prolonged relief from procaine, one would prefer an anesthetic agent of longer lasting properties. Eucipin in oil has produced anesthesia up to 3 or 4 days and has been a useful material. Ammonium sulfate, which Bates and Judovich find has a particular affinity for the fine C pain fibers, can be infiltrated widely into tissues without undue reaction, but the ideal agent for prolonged abolition of pain without excess tissue damage remains to be discovered. The only points at which alcohol may be injected safely in headaches of scalp origin are the supraorbital nerves at their exit from the skull and the third division of the trigeminal at the foramen ovale when the auriculotemporal region is involved.

Operative treatment has been most valuable when excision of tender areas in a scar is performed. Recurrence of pain is unusual. On the other hand, section of main trunks of scalp nerves

is frequently disappointing. When local tenderness alone, without a definite local lesion, is present, the headache is likely to reappear in another location. Even in cases with local pathology, nerve section is frequently followed by recurrence of pain in about 6 months, presumably the result of nerve regeneration. Crushing the nerve with a hemostat proximal to a silk ligature has been used in an effort to limit such undesirable nerve regeneration. This matter requires further study.

There are a number of therapeutic considerations of value in supplementing surgical treatment of headaches from localized lesions of scalp nerves. Whether the widespread use of large doses of thiamine chloride in all types of nerve lesions has any proved value is doubtful, but we all use it. When there is evidence of vasoconstriction or sensitivity to cold, flushing doses of nicotinic acid have seemed useful. Prostigmine bromide (now used in all neuromuscular disorders from the flaccidity of myasthenia gravis to the extreme spastic contractions of black widow spider bite) has helped some cases with tenseness of occipital muscles. In this regard, postural strain caused by bending over a desk or typewriter may be an important factor in occipital neuralgias.

Aggravation of headache after injury to scalp nerves may be caused by pressure of headgear on sensitive areas, particularly in the frontal region and to a lesser extent in the occipital. A tight hat band may cause symptom-provoking constriction. Heavier gear, such as the protective helmets required in certain industries, frequently cause discomfort sufficient to make the worker discard this safety appliance and take his chances on a repeated injury. The female of the species has accidentally overcome the effects of hat band pressure in producing headache. Ladies are generally relieved of this hazard as a by-product of their desire to improve on the original function of the hat as a mere head covering. Either on the face or off the face, structural properties of present-day ladies' hats cause little pressure on any scalp area, but are perched jauntily on the coiffure, to enhance the decorative effect. This is not to deny the well recongnized psychologic uplift of a new bonnet.

In summary, a general discussion has been presented indicating that some cases of localized chronic headache are related to lesions of scalp nerves. A search for such lesions may lead to the possibility of local surgical treatment. The methods of treatment and prevention of recurrence require further study.

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Many of the points presented in this paper are obviously not original with the author. A review of pertinent literature will be reported in a subsequent communication.

THE TREATMENT OF PENETRATING WOUNDS OF THE BRAIN PRODUCED BY MISSILES OF WARFARE

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From time immemorial the piercing of the skull has been a common method used by the warrior to dispose of the enemy in rapid fashion. That the same is true of modern warfare is attested by the fact that out of 1000 autopsies performed on battlefield fatalities by the Second Medical Laboratory in Italy, 401 had wounds of the head capable of causing death, approximately 133 of these having head wounds only.[1] This report deals with the treatment of penetrating wounds of the skull involving the brain produced by missiles of warfare. All civilian types of injuries, scalp lacerations and compound fractures not produced by missiles are therefore excluded. The methods and principles to be described are those which were used in an evacuation hospital during World War II.

From Oct. 15, 1943, to May 2, 1945, during the Italian Campaign, approximately 12,000 battle casualties were admitted to this evacuation hospital. Among this group there were 126 penetrating wounds of the brain. Nineteen of these did not survive a sufficient length of time to have surgery, giving an immediate mortality of 15 per cent. One hundred and seven had primary debridement of brain wounds and in this group there were 8 deaths, giving an operative mortality of 7.5 per cent.

PREOPERATIVE CONSIDERATIONS

In evaluating a patient with a compound wound of the brain, surgical first principles must be strictly adhered to and therefore the general status of the patient is of prime importance. A thorough examination is necessary and this should be done with all clothing stripped away in order to get a true perspective of the situation and avoid overlooking important signs. A few minutes spent conducting a general inspection will at once reveal the posture of the patient, his spontaneous movements, facial expression, color and type of breathing. Associated wounds are often present and whether their treatment is more urgent than the head wound must be decided in each individual case.

The general examination having been completed, one should then examine the head thoroughly in order to ascertain the posi-

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tion and extent of the wound. Digital examination and probing of the wound are mentioned merely to condemn such procedures. Such explorations are apt to disseminate infection and may start troublesome bleeding which is not easy to control by simple means.

Every patient with a brain wound should have a thorough neurologic examination in order to determine the location and extent of neural damage. Even in times of great stress, sufficient time should be taken to determine and record the state of consciousness, size, shape and reaction of pupils, presence or absence of paresis, gross sensory changes, and, finally, the reaction of superficial and deep reflexes. The results of these findings are absolutely mandatory to enable one to come to a logical conclusion concerning the exact lesion to be dealt with and thereby treat the patient on a scientific basis. Focal or Jacksonian convulsions are indicative of cortical irritation which may readily be localized by the pattern of the seizure. Unilateral pupillary dilation with fixation when associated with unconsciousness points almost certainly to an intracranial hematoma of surgical significance and, therefore, should have immediate attention. Such hematomata may be intracerebral, subdural or extradural. In the main, hematomata are usually associated with small penetrating wounds as a result of which free escape of blood has not been permitted.

Since the nature of a cranial injury can aid in the diagnosis of the underlying cerebral state, a preoperative x-ray examination of the skull must never be omitted as this gives direct evidence of what otherwise must often be conjectural. It will reveal the extent of bony injury, the approximate number and exact location of in-driven bony fragments, and the presence or absence of radiopaque missiles, such as bullets or pieces of shrapnel. The bony damage found at operation is usually more extensive than that depicted by x-ray. Too, one should not rely on x-ray to demonstrate all of the small in-driven bone chips but should depend more on a thorough debridement of the tract under direct visualization.

Primary shock has been described as a condition of collapse which may follow soon after an injury and which is not due to hemorrhage. Its underlying physiopathologic cause is ill-understood. Primary shock in varying degrees not infrequently follows soon after the receipt of a brain wound. It differs somewhat from the shock produced by other injuries and is thought by some to be due to vasomotor paralysis of central origin and is, therefore, a component part of general brain insult. The primary shock associated with brain wounds usually responds readily to rest, heat and plasma. Shock secondary to massive hemorrhage

from large scalp wounds or wounds implicating one of the major cranial venous sinuses is often met with. It is to be noted that the usual picture of secondary shock, that is to say, pallor, sweating, vomiting, rising pulse rate and falling blood pressure, is difficult to distinguish from the picture due to a failing cerebral circulation directly produced by an injury to the brain. Secondary shock due to hemorrhage from the scalp or venous sinuses responds to the administration of large volumes of blood. Where the loss has been great, as much as 1500 c. c. or 2000 c. c. of whole blood may be necessary before the patient improves sufficiently to tolerate surgery. Two cases with brain wounds associated with transection of the superior longitudinal sinus were admitted in an unconscious state with a barely palpable rapid radial pulse and with a blood pressure which was not obtainable. Both patients required drastic supportive therapy which was effective even though this delayed the operative procedure by many hours. The ideal time to operate on a patient with a brain wound is within eight hours of the receipt of the injury; however, when in doubt about the ability of a patient to withstand a cranial operation, it is better to wait than be in a hurry. At any rate, it is unwise to operate on a patient before he has recovered from the secondary shock and sufficient time has elapsed to allow for adequate fluid replacement. Therefore, by observing surgical first principles, many disastrous results may be avoided.

During periods of stress, when the flow of patients is heavy, one may find in the preoperative tent three or four patients with brain wounds awaiting operation. One is, therefore, confronted with the problem of establishing priority. In general, it is permissible to give precedence to those head wounds with the better prognosis and to delay operation on the so-called moribund cases. The all too familiar picture of a deeply comatose patient with rapid stertorous respirations, rapid pulse, and wide pulse pressure is an ill omen known only too well by those surgeons accustomed to dealing with penetrating wounds of the brain. Such a picture represents the terminal phase of severe brain damage and there is little to be expected from surgery. Decerebrate rigidity is another important sign which points to a poor prognosis. It is a primitive postural state in which the muscles of the limbs go into a state of extreme hypertonus in a position of extension. In my limited experience I have never witnessed the survival of a patient with a penetrating wound of the brain which was associated with decerebration, regardless of the type of therapy administered. Therefore, decerebrate rigidity in the presence of a brain wound is considered a grave sign. As a result, such cases are usually given a low priority.

Anesthesia

Local anesthesia is the anesthetic of choice in the treatment of compound brain wounds and should be used whenever possible. It is safer than other methods and as a surgeon becomes accustomed to its use he realizes its advantages. By this method intracranial pressure is kept at a minimum and troublesome oozing is avoided. Ether and most of the general anesthetics cause an increase of the intracranial pressure and in the presence of a large dural defect may initiate or increase an existing cerebral herniation. Moreover, the added tension may be sufficient to make intracranial maneuvers difficult or dangerous.

Restlessness may be due to pain in the wound owing to inadequate anesthesia, postural discomfort or suffocation. When a patient continues to be restless for reasons other than faulty technic, it is advisable to supplement the local anesthesia with the intravenous administration of pentothal sodium. Pentothal is a safe and excellent anesthetic in the hands of an experienced anesthetist. General anesthesia is also indicated when the edges of the lacerated scalp are so badly abraded that the process of shaving is impossible without causing an undue amount of pain. Cranial surgery carried out concomittantly with other major surgery has not been satisfactory; therefore it has been the custom to do the brain wound under local anesthesia first and then care for the associated wounds under general anesthesia. By this system, the increase of intracranial tension associated with general anesthesia does not produce cerebral herniation inasmuch as the dural defect has been closed previously. This system also considerably shortens the duration of the general anesthetic. When inhalation general anesthesia is unavoidable, gas, oxygen and ether administered through an intratracheal tube is a good method.

During the Italian campaign, 107 penetrating wounds of the brain were debrided at this evacuation hospital. Seventy-four of these operations were done under local anesthesia (1 per cent novocaine). Twenty-one operations were done under local anesthesia supplemented by small amounts of pentothal sodium. The amount of pentothal varied from 0.5 to 1.5 grams. Only a small amount of pentothal was needed in order to convert a restless, irritable, straining, uncooperative patient to a quiet, peaceful state. Pentothal was chosen to supplement the local anesthesia because of its quick action, rapid elimination and the fact that it does not increase intracranial pressure. Endotracheal ether was used in 9 cases. It is to be noted that the use of an

endotracheal tube insures a good airway and, therefore, quiet respirations.

Operative Technic

The primary aim in the operative treatment of penetrating wounds of the skull is the surgical cleansing of the tract made by the projectile. This is accomplished by the removal of damaged tissue and of any foreign material which is not too deeply embedded. The importance of careful, gentle, thorough debridement of the wound from the scalp to the depth of the tract cannot be too strongly emphasized. The prevention of sepsis is synonymous with adequate wound excision and removal of debris, and it is very wrong to regard chemotherapy as the panacea against infection. In this discussion, the various steps of operative procedure for the debridement of brain wounds will be dealt with under the headings of scalp, bone, and brain.

Scalp:

The primary aim of a scalp debridement is to trim away the devitalized tissue and to remove foreign bodies from the depth of the wound. The amount of tissue to be excised will depend

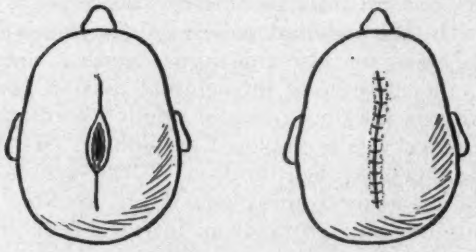

Fig. 1. Elliptical excision and closure.

upon the degree of contamination, size, shape, and raggedness of the wound. The excision should be done with a sharp scalpel and all devitalized tissue removed; however, the excessive removal of skin is quite unnecessary and will only lead to a difficult closure.

The galea moves freely over the pericranium and thus the edges of a wound may be mobilized and retracted for wider exposure. Such undermining may be all that is necessary in order to effect wound closure. If there has been considerable loss of tissue, closure may be had by suitable incisions and sliding of the scalp. The conversion of a defect into a long ellipse is the simplest method of effecting closure when loss of tissue has not been great.

(fig. 1). When a wound is irregular and much tissue has been lost, the S-shaped incision or tripod incision of Cushing are more suitable for facilitating exposure and closure (fig. 2). Their

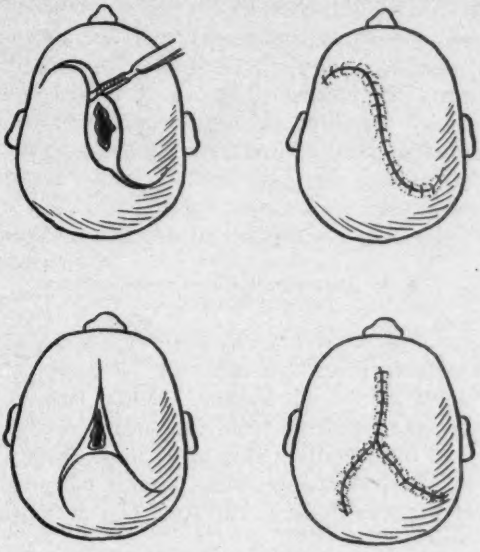

Fig. 2. S-shaped and tripod incisions.

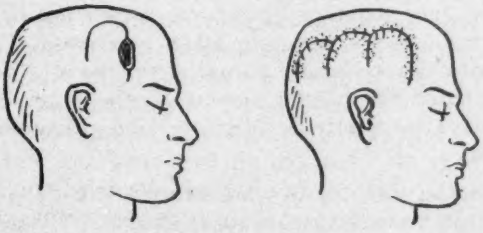

Fig. 3. Semicircular skin flaps for mobilization of scalp.

use should be confined to cases where there has been considerable loss of tissue. The S-shaped incision is preferred over the tripod incision because of the common occurrence of necrosis at the tip of the V in the tripod incision. On the other hand, the triradiate incision gives better exposure than any other type of wound extension. Where tissue loss has been too great for closure without tension, the scalp may be mobilized by a series of successive flaps (fig. 3). A horseshoe-shaped flap with inclusion of the wound

in the center may be used. It affords wide exposure and is particularly useful where the soft tissue wound is only moderate in size and the bone pathology is rather extensive (fig. 4). Relaxing incisions that are allowed to gape in order to effect sliding of the

Fig. 4. Horseshoe flap with wound inclusion.

edges of the original wound to cover an exposed area of brain are at best unsatisfactory and should only be used as a last resort when other methods do not suffice. When lateral incisions are used, the bare area resulting from the sliding of the scalp can be covered with an intermediate skin graft immediately or at a later date. On the three occasions when lateral incisions were necessary, the grafting was done at the time of the debridement with gratifying results.

When the loss of tissue has been great, it is well to remember that apposition of the skin edges by force is useless because the margins of the wound will slough and separate. If the scalp edges cannot be brought together by sutures passed through the galea, then the tension is too great to allow good wound healing and further plastic procedures as outlined above are necessary. Not infrequently the plastic closure of the scalp over a brain wound resolves itself into a job more time-consuming than the debridement.

Closure of the scalp in two layers with silk or cotton sutures in an interrupted manner is always desirable. By so doing, postoperative subgaleal hematomata are less apt to occur and, too, the skin sutures may be removed in 48 to 72 hours and thereby minimize the chance of superficial infections.

Bone:

As all open wounds are potentially infected, the instruments used for the excision of the skin are discarded before taking care of the deeper structures and the operative field is draped with additional sterile towels. The periosteum is incised for a distance of 1.0 cm. beyond the periphery of the cranial defect. The contaminated periosteum is then swept from the bone by a broad

periosteal elevator or a piece of gauze stretched over the index finger.

In penetrating wounds of the skull it is necessary to remove considerable bone surgically to cleanse the wound and to afford adequate room for the debridement of the deeper tissues. It is a good policy to remove a sufficient amount of bone to expose a cuff of healthy dura 1.0 cm. wide around the circumference of the wound. Often cerebral tissue will be found protruding through the bone opening and troublesome bleeding from the inadvertent tearing of a cortical vein can readily be avoided by placing a burr hole in adjacent sound bone over intact dura from which the bone removal can be carried out with ease by means of bone-cutting forceps.

After sufficient bone has been removed, one may embark upon the debridement of the deeper structures. Only the devitalized tags of a ragged dural tear should be removed. In fact, debridement of the dura in most instances is unnecessary. In no case should the dura be extensively excised as this may reopen meningeal spaces which have already been sealed off. Careful inspection of the wound at the dural-cortical junction for small bone chips can usually be carried out without breaking the seal and thereby minimize the chance of meningitis. Closure of the dura is always desirable in order to prevent the formation of a cerebral fungus and to prevent intracranial extension in the event of a superficial wound infection. The dural tear should be sutured if retraction or loss of tissue has not made this impossible. Repair of the dura by grafting is not difficult and should be resorted to if simple suturing cannot be done without tension. Dural sutures under tension are certain to slough. In more than half of the cases in this series, it was necessary to use grafting as a means of closing the dura. When dural tissue has been lost and the defect is large, fascia lata has been used for closure. On the other hand, for repair of small defects, pericranium obtained from a healthy part of the wound is convenient. The graft is cut to conform to the shape of the defect and sutured to the dural edges with its smooth surface facing the brain. Interrupted sutures of fine silk or cotton are desirable for closure of the dura.

The debridement of war wounds of the brain requires the same special operative technic used in civilian neurosurgery. The gentle handling of tissues and absolute hemostasis are details which must be observed meticulously if catastrophes are to be avoided. Rough handling of the brain will only lead to swelling which may prove fatal. Hemostasis must be complete and until this has been secured it is useless to close a wound, since a postoperative clot is certain to form and compress the brain. All

bleeding points should be isolated and promptly controlled by coagulation, application of silver clips or muscle grafts. A bloodless field is desirable in order to carry out the debridement of the tract under direct vision and, therefore, each bleeding vessel should be sealed by an appropriate method before proceeding further.

Foreign bodies and bone chips may be picked from the superficial portion of the wound with forceps and loose tissue washed away with warm saline. Access to the deeper portion of the wound is obtained by opening the tract with flat, metal lighted brain retractors of the Frazier type. These retractors afford good exposure and efficient lighting which are necessary. If lighted retractors are not available, the ordinary brain retractor used in conjunction with a head light will suffice. Moistened strips of cottonoid are placed along the walls of the wound tract to protect the brain from further damage. Debridement is then carried out from the superficial portion to the deepest part of the wound by means of suction and irrigation. Weak suction is used so that only damaged tissue will be removed. Jets of warm saline may be used to advantage to disengage small bone chips from blood vessels. Small bone fragments may be picked up by the suction tip and then removed. Large bone fragments and missiles are best removed with forceps under direct vision. Great care should be taken not to remove healthy brain tissue as this is apt to open new avenues for infection or lead to unnecessary neural defects. In highly specialized areas of the brain such as the motor cortex and the optic centers, the debridement should be rather conservative in order to avoid a resulting hemiplegia or marked restriction of the visual fields.

A deeply embedded metallic foreign body should be removed immediately if it can be reached safely along the wound tract without infliction of further damage to the brain. If, on the other hand, a bullet or shell fragment is not accessible through the wound of entrance, it is not advisable to make a separate opening through the skull for its extraction. Even the most deeply embedded fragments when visualized may be removed with long bayonet forceps. It has been found that the electric magnet is not useful for the extraction of metal fragments.

Retained metal missiles rarely give rise to brain abscess and when not easily accessible should be left in situ. On the other hand, the most common cause of postoperative brain abscess is the presence of bone chips overlooked at the time of the initial debridement. It is to be remembered, too, that an epileptogenic focus tends to lie in the cortical part of the brain rather than the depth and therefore the incidence of convulsive states should

not be materially affected by the presence of a deeply embedded metal fragment. If complications such as infection and convulsions develop, removal of a foreign body at a later date may be necessary.

Intracerebral hematomata of sufficient size to be of surgical significance are not uncommonly found in association with penetrating wounds of the brain. Sixteen of the 126 cases in this series had sizable intracerebral hematomata, an incidence of 12.7 per cent. The clots varied in diameter from 2.5 cm. to 4.0 cm. For the most part, these patients had some evidence of increased intracranial tension. The brain was usually tight and the patients were more stuporous than one associates with an ordinary penetrating wound of the brain. Six of the 126 patients had large subdural hematomata, an incidence of 4.7 per cent. This does not differ materially from the frequency of subdural hematomata encountered in closed head injuries of civilian life. Five of the subdural hematomata were located about the brain wound. In one instance the hematoma was at a distant site. Shorstein[2] has recently emphasized the hazard of such concealed clots. The syndrome is characterized by a small penetrating wound associated with gradual onset of stupor, signs of intracranial tension and a small, deeply embedded foreign body in the vicinity of the falx. These concealed subdural hematomata are rare; however, the possibility of such must be kept in mind in order to institute appropriate surgery to prevent a fatal termination.

Wound Closure:

The ultimate ideal to be attained in the treatment of penetrating wounds of the brain is closure without drainage with primary wound healing. All cranial wounds in this series which were thought to be free from infection were closed without drainage except for the exceptional case when the missile tract implicated one of the paranasal sinuses. Wounds involving the air sinuses are a special problem and will be dealt with separately. If it has been decided that infection is already present and that drainage is necessary, a narrow strip of rubber is placed beneath the scalp and brought out through what will be the most dependent part of the wound. Drainage is rarely necessary in wounds not complicated by involvement of the air sinuses. Intradural drainage is usually ineffective and therefore should never be employed.

Special Types of Wounds

Wounds involving the dural venous sinuses, the air sinuses and the ventricles of the brain present special problems and, therefore, deserve separate comment.

Dural Venous Sinuses:

The closure of a torn dural venous sinus is difficult and often hazardous from the standpoint of profuse bleeding. Therefore, in dealing with depressed fractures or penetrating wounds of the brain implicating the superior longitudinal or lateral sinus, certain preoperative precautions should be taken in anticipation of bleeding. One liter of compatible blood should be obtained. When the patient is placed on the operating table, his head is raised well above the level of the rest of the body in order to lower the cerebral venous pressure. Bleeding from the longitudinal sinus is greatly reduced in the upright position and whenever feasible, the sitting position is desirable. Before starting the cranial operation, muscle grafts are taken from the leg and a saline drip started in order that blood may be given without delay when necessary. General anesthesia by inhalation should be avoided at all cost because this will often cause serious bleeding before one is prepared to control it. Local anesthesia is the method of choice and in case of restlessness pentothal sodium intravenously is ideal as a supplement.

After the superficial layers of the head wound have been excised, one must reach a decision as to the best method of dealing with the bone. In the event that the torn sinus is associated with a penetrating wound of the brain and there is a sizable, regional bony defect, one may proceed carefully to lift out the bony fragments singly, starting at the point fartherest away from the sinus and working toward it until the dural tear is fully exposed. The danger of this method is that severe bleeding may be started before enough bone has been removed for good exposure. If this happens, one must proceed as rapidly as possible with bone removal. On the other hand, if the bone pathology is that of a comminuted depressed fracture, the interlocked fragments are best removed by block resection. By so doing, the rent in the venous sinus is at once exposed under circumstances that permit the surgeon to deal with vigorous bleeding.

When a sinus is found to be completely severed, each end may be clamped with mosquito forceps and ligated with silk sutures. On three occasions when dealing with penetrating wounds of the brain, the superior longitudinal sinus was found to be transected and a thrombus in the cut ends. In these cases, the sinus was ligated in the customary fashion lest the thrombi be expelled by sudden rise of venous pressure on coughing or straining. When the tear is extensive, it may be closed by interrupted sutures of fine silk; however, it is almost always necessary to reinforce the suture line by a muscle graft in order to control the last final

oozing of blood. The muscle graft may be held in position by passing a guy suture over its top, the ends of the suture having been anchored to the dura on either side of the sinus.

Frontal Sinus:

The frontal air sinus, because of its position and size, is particularly vulnerable to injury. Penetrating wounds of the brain produced by missiles traversing the frontal sinus deserve special consideration if troublesome fistulae and fatal infections are to be avoided. In such cases, the superficial part of the wound is excised and the mucous membrane removed before debridement of the brain is undertaken, so as to make the operation as aseptic as possible. The bony fragments driven inward from the anterior wall are carefully picked out. The debridement of the bone must be thorough and all loose fragments should be removed; however, every effort must be made to conserve the supra-orbital ridge, otherwise an unsightly deformity will result. The bony defect in the posterior wall of the sinus is then debrided widely so as to expose at least a 1.0 cm. cuff of normal dura. The instruments used for the superficial wound excision are now discarded and the wound enlarged transversely if further exposure is necessary. We have never found it necessary to resort to the more arduous task of reflecting a frontal bone flap even though at times it has been necessary to debride a rather deep tract in the brain through a relatively small opening. The brain is then debrided in the usual fashion. Firm closure of the dura in these cases is of paramount importance to prevent intracranial infection. Dural repair may be secured by means of fascia lata grafts.

The question of drainage in these cases is a debatable point. There are those who claim that drainage is useless and ineffectual, while others insist on drainage in one form or another for a period of 48 hours. All agree that the forehead wound should be closed and drainage, if decided upon, should not be instituted through the wound over the sinus lest a troublesome and unsightly fistula develop. It is recommended that only those wounds be drained which are heavily contaminated, those with a previous history of sinusitis, and those with a time lag of more than 12 hours. When drainage has been decided upon, a narrow strip of rubber tissue is brought from the sinus through a subgaleal tunnel to a small stab wound in the temporal region within the hairline. The long drainage tract obviates the formation of a fistula and also places the drainage site in a location so as not to leave a visible scar.

Ventricular Wounds:

Reports concerning wounds of the ventricles of the brain from World War I emphasized the high mortality rate. This was

attributed for the most part to the lack of a barrier against infection once the missile transversed the ventricular system and also the ease with which any introduced infection may be quickly disseminated by the circulating cerebrospinal fluid. Although infection still claims its toll, certainly in this war its dangers have been reduced by improved therapeutic measures.

Among 126 penetrating wounds of the brain in this series, the ventricles were implicated in 18 cases, an incidence of 14.3 per cent.[3] Three of the 18 patients with ventricular wounds died without surgery. All of these had short survival periods, vital signs indicative of impending death, severe brain damage, which was bilateral in two instances and unilateral but bipolar in one.

There were 15 operative cases and in all there was a paucity of leads indicating ventricular involvement. In general, these patients presented clinically the picture of a severe brain wound. All had a period of unconsciousness. Only in one case was there a sufficient amount of cerebrospinal fluid drainage from the wound to point to the diagnosis of a wound of the ventricle.

The operative principles for the treatment of wounds of the ventricles are the same as in any penetrating wound of the brain. In dealing with a wound suspected of implicating the ventricle, it is well to keep irrigation to a minimum in the early stages of the debridement, lest blood clots, small bone fragments and debris be washed to a distant and inaccessible portion of the ventricle. It is also necessary to be extremely meticulous about complete hemostasis in the presence of a ventricular wound because of the added danger of postoperative hematomata due to the existing cavity which may act as a reservoir. In these wounds, tight closure is also of the utmost importance in order to obviate the danger of the laking of cerebrospinal fluid in the subgaleal region or the subsequent formation of a cerebrospinal fluid leak. In an effort to obtain watertight closures, it was necessary to use living fascial or periosteal grafts in 13 of the 15 operative cases in this series.

In treating ventricular wounds, it is a good policy to leave 10,000 units of penicillin in the open ventricle at the conclusion of the operation and to give sulfadiazine, either by vein or by mouth, in sufficient quantities to maintain a satisfactory blood level. The intrathecal administration of penicillin should be reserved for wounds with an excessive amount of contamination, for those cases with a long time lag, and, finally, for those with obvious signs of intracranial infection. When intrathecal penicillin has been resorted to, a daily dose of 10,000 units is advisable. This chemotherapeutic routine has been used since penicillin was made

available. In 11 out of 15 cases, 10,000 units of penicillin were left in the ventricle and in 4 cases, treated before the days of penicillin, the brain tract was treated with a generous dusting of sulfanilamide powder.

Frequently one sees a sterile ventriculitis in patients with wounds of the ventricles during the postoperative period. This reaction is presumably set up by the drainage of damaged, sloughing, glial tissue from the brain tract into the ventricle. The condition is characterized by fever, stiff neck, mild to moderate pleocytosis and, in severe cases, even delirium. It is sometimes difficult to distinguish from bacterial ventriculitis; however, in the latter the common signs and symptoms are more severe, the course is rapid, the pleocytosis is much greater and usually bacteria may be isolated from the cerebrospinal fluid. Differentiation between these two types of ventriculitis is important inasmuch as immediate intrathecal penicillin therapy is indicated in the bacterial ventriculitis and is contraindicated in the sterile ventriculitis.

There were two deaths among the 15 operative cases with wounds of the cerebral ventricles, giving an operative mortality of 13.2 per cent. Because of the short holding period in the evacuation hospital and because of the small number of cases involved, these figures lose much of their significance. It is interesting to note, however, that the operative mortality in this series for wounds involving the ventricles was twice that for the ordinary penetrating wounds of the brain. One death in this group was due to bilateral bronchopneumonia with multiple pulmonary abscesses and the other death was due to massive brain damage. It may be pointed out that intracranial infection did not play a role in these mortalities. This is in contradistinction to what happened in World War I. Therefore, with the advent of chemotherapy, infection no longer plays a dominant role as a cause of death once the ventricles have been penetrated. The lethal factor in these wounds has been massive brain damage, particularly the paraventricular structures.

Local and Systemic Chemotherapy

The consensus, based on World War II experience, is that early and careful debridement of a wound is the essential factor in attaining primary healing and that the use of chemotherapy, both locally and generally, plays a secondary role. Chemotherapy is undoubtedly of value and its effectiveness should not be minimized. However, it cannot be expected to replace good surgery. In no way should surgical first principles be altered

with the expectation of the sulfonamides and penicillin filling the gap.

During the early days of the Italian campaign sulfanilamide powder was applied locally to brain wounds following debridement. Sulfanilamide was chosen over sulfathiazole due to the tendency of the latter to cause convulsions. The finely powdered sulfanilamide was placed in the tract by insufflation, great care being taken not to allow the drug to come in contact with the cortex. After dural closure, sulfanilamide powder was applied to the superficial portion of the wound. Sulfadiazine was given systemically in quantities sufficient to maintain a satisfactory blood level.

Sixty-one penetrating wounds of the brain were treated with local application of sulfanilamide and the systemic use of sulfadiazine. Among this group of cases there were 9 wound infections, an incidence of 14.7 per cent. All wounds which drained are included in this report even though smears of the drainage material did not always reveal the presence of bacteria. There were 5 superficial wound infections, 2 anaerobic infections, one brain abscess and one deep wound infection with a cerebrospinal fluid leak. The two anaerobic infections were successive cases. The drainage material from both was a rusty color and a smear showed large gram positive bacilli. The infection in both instances was associated with gas formation. Unfortunately, cultures were not available at the time.

When penicillin was made available for general use in the Italian theatre, it was used in the treatment of penetrating wounds of the brain. It was used locally, systemically, and, in certain instances, it was used intrathecally. Table I depicts the various combinations in which penicillin was used, both with and without sulfonamides. In general, penicillin was applied locally when the brain wound implicated the ventricle and in a few instances where the brain wound was large and resulted in a large cavity. For the most part, when penicillin was used locally, sulfadiazine was administered systemically inasmuch as penicillin does not pass the blood brain barrier in quantity. In those instances where the brain wound was associated with other wounds, 25,000 units of penicillin were given intramuscularly every three hours as well as sulfadiazine in sufficient quantity to maintain a satisfactory blood level. When penicillin was used locally, 10,000 units dissolved in 2 c. c. of distilled water were left in the ventricle or brain wound. Intrathecal administration was reserved for those cases with excessive contamination linked with a long time lag and those with suspected intracranial infection. In most instances of intrathecal therapy, a daily dose of 10,000 units of

penicillin was used. It may be seen from Table I that penicillin in numerous different combinations was used in 43 cases with the development of 4 infections, an incidence of 9.3 per cent. Two of the complications were superficial wound infections. One patient developed meningitis while still another had a non-suppurative

TABLE I

PENICILLIN AND SULFANILAMIDE THERAPY IN 43 PENETRATING WOUNDS OF THE BRAIN

Local Drug	Systemic Drugs	Intrathecal Drug	No. of Cases	Infections
1. Penicillin.....	Sulfadiazine.....	****	10	0
2. None.....	Sulfadiazine and Penicillin.	****	8	0
3. Penicillin.....	Sulfadiazine and Penicillin.	****	5	1 Superficial wound infection.
4. Penicillin.....	Sulfadiazine and Penicillin.	Penicillin...	3	0
5. Penicillin.....	Penicillin.....	Penicillin...	3	0
6. Sulfanilamide..	Sulfadiazine and Penicillin.	****	4	0
7. Penicillin.....	Penicillin.....	****	2	0
8. Sulfanilamide..	Penicillin.....	****	1	1 superficial wound infection.
9. None—at reoperation, Penicillin.	Penicillin.....	Penicillin...	1	1 cerebritis survived.
10. None.....	Sulfadiazine and Penicillin.	Penicillin...	2	1 meningitis survived.
11. None.....	Penicillin.....	****	4	0
		Total	43	4

cerebritis. It is of interest to note that before the days of penicillin, our wound morbidity was 14.7 per cent as compared to 9.3 per cent after penicillin was made available. These statistics are of limited value because of the small number of cases involved, the many combinations of chemotherapy used, and the limited follow-up data, inasmuch as the holding period varied from 2 to 23 days. Undoubtedly, some of these patients were evacuated before ample time had elapsed for signs of late infection to appear.

Postoperative Care

The postoperative care of patients with cerebral wounds is equally as important as the operation itself. This is particularly true in instances of unconsciousness or restless stupor. Time

spent in training ward personnel will pay dividends in the form of understanding care of those who are unable to help themselves. The hourly recording of the blood pressure, pulse and respiratory rates not only gives information regarding the postoperative course but serves to emphasize the necessity of almost constant watchfulness over those suffering from brain wounds. Personnel in attendance should be taught to keep up a vigilant watch for changes in the state of consciousness, the appearance of paresis of an extremity, and the development of convulsions. All of these are signs of moment and should be reported immediately to the surgeon in charge.

Patients who are unconscious should be left flat in bed, preferably on their side, in order to facilitate drainage of secretions from the mouth and should be turned every hour in an effort to avoid pneumonia. Aspiration of the trachea at frequent intervals is necessary to insure unobstructed respiration. For patients who are conscious, we prefer a modified Fowler's position. The elevation of the head diminishes the venous pressure and thereby facilitates venous return.

Restlessness is thought to be due in part to overaction of the subcortical centers which have been released from the influence of higher centers. Therefore, it is wrong to control movements by restraints as this is apt to serve as a further stimulus. At times sedation is necessary for these patients; however, it was felt that these drugs should be used sparingly. Small repeated doses of hypnotics are much to be preferred over large single doses. Morphine is to be avoided because of its depressing effect on the respiratory center and is rarely needed except in the presence of severe, painful, associated wounds. Codeine and aspirin are quite sufficient for the control of headache in conscious patients with cranial wounds.

The restoration of a normal fluid balance and the replacement of blood loss in the wounded requires more attention than in the ordinary postoperative cases in civilian life. The wounded entering an evacuation hospital are usually dehydrated due to diminished fluid intake under battle conditions concomitant with blood loss of varying degrees. Blood and plasma are given preoperatively and during operation in sufficient quantities to combat shock. In the early postoperative period it is also necessary in many instances to give large quantities of blood in order to obtain a normal blood picture. Restoration of a normal blood picture is necessary if good wound healing is to be secured.

It has been our feeling that a normal fluid balance is more desirable than any beneficial effects to be expected from dehy-

dration. Therefore, we have allowed 3000 c. c. of fluid daily in the immediate postoperative period.

The prevention and control of increased intracranial pressure at times becomes a problem during the early postoperative period of penetrating wounds of the brain. The tension seldom reaches an alarming degree; however, reduction is sometimes necessary. One must consider the general condition of the patient as well as the status of the brain in choosing the method to reduce the intracranial pressure. Dehydration is seldom justifiable in the presence of other extensive wounds because of the danger of damaging other tissues of the body in an attempt to overcome hypothetical cerebral edema. Injections of 50 per cent glucose or sucrose were used in rare instances. On the other hand, lumbar punctures at frequent intervals were resorted to as a procedure to combat cerebral edema in the few cases where such has been necessary. Care should be taken to reduce the pressure slowly in order to prevent tentorial herniation or coning of the cerebellar tonsils.

Early Complications

The holding period in the evacuation hospital from which this series is taken varied from 48 hours to 23 days. Needless to say, many of the patients were evacuated before sufficient time had elapsed for the development of late complications. This discussion deals with the early complications following penetrating wounds of the brain. Table II shows in some detail the various complications encountered.

The brain is able to overcome mild infections or to localize suppurative processes by the formation of fibrous tissue. Therefore, wounds of the brain do not necessarily lead to meningitis or to a spreading cerebritis. Spread of infection over the cortex is limited somewhat by the obliteration of the subarachnoid space by swelling of the brain and by meningeal adhesions in the region of the wound. It is of interest to note that more than half of the complications were local wound infections or intracranial infections. Those cases with a small amount of serosanguinous drainage and negative smears (cultures not available) for bacteria have been listed as mild infections. Those which had purulent drainage with organisms demonstrable by smear have been designated as severe wound infections.

When a wound shows signs of superficial suppuration, it should be opened widely to allow free drainage lest the infection spread to deeper structures. Tight closure of the dura at the time of the debridement not only serves as a barrier against intracranial

TABLE II

EARLY COMPLICATIONS IN 107 PENETRATING WOUNDS OF THE BRAIN

I.	Wound and intracranial infections	
	A. Mild wound infections	5 cases
	B. Severe wound infections	4 cases
	C. Cerebritis	1 case
	D. Meningitis	1 case
	E. Abscess	1 case
	F. Ventriculitis	1 case
II.	Cerebrospinal fluid leak	2 cases
III.	Postoperative Jacksonian convulsions	3 cases
IV.	Postoperative hematoma, intracerebral	1 case
V.	Aseptic ventriculitis	1 case
VI.	Wound dehiscense	1 case
VII.	Bilateral bronchopneumonia and multiple small lung abscesses	1 case
VIII.	Parotitis	2 cases

spread of the infection in the event of a superficial wound infection but also prevents fungus formation after the wound has been opened. Dural patches may remain in situ even in the presence of an infection in the superficial portion of the wound. In one case which developed a brain abscess, pus was found epidurally yet the dural patch remained intact.

Lumbar puncture should be performed immediately when signs of an intracranial infection develop in a patient who is convalescing from a brain wound. The cerebrospinal fluid should be examined for cells and bacteria. Appropriate chemotherapy should be instituted at once. The one case of nonsuppurative cerebritis of this series was successfully treated by daily injection of 10,000 units of penicillin intrathecally and 25,000 units of penicillin intramuscularly every three hours. This patient recovered in spite of the fact that intracranial tension was sufficiently high to produce papilledema and bilateral sixth nerve palsy. The diagnosis of this case was based on fever, marked pleocytosis, leukocytosis, rapid development of intracranial tension and lack of local suppuration as disclosed at reoperation.

Meningitis is not common as a complication. The one case referred to in Table II was that of a soldier with a penetrating wound of the brain traversing the mastoid cells with a comminuted fracture of the petrous pyramid. No bacteria were demonstrable on direct smear of the cerebrospinal fluid (cultures not available); however, because of fever, rigid neck, pleocytosis and the nature of the wound, it was deemed necessary to carry out therapy for meningitis. Both sulfadiazine and penicillin were given systemically and 10,000 units of penicillin were administered intrathecally daily with a favorable result.

The ependymal lining of the ventricles of the brain affords little or no barrier against infection and once an infection becomes established in the ventricular cavities, the picture of a diffuse meningitis rapidly ensues. The one case of ventriculitis encountered in this series was still febrile when evacuated 21 days postoperatively for tactical reasons in spite of sulfadiazine and penicillin systemically as well as the intrathecal administration of penicillin.

It is of interest to note that 25.7 hours was the average time lag for those cases in our series which developed wound or intracranial infections. Only two cases had a time lag of 10 hours or less. The remaining 11 cases had time lags which ranged from 13 hours to 4 days. This would tend to substantiate the contention that early debridement is the greatest single factor to insure primary wound healing. It was pointed out under the discussion of chemotherapy that our wound morbidity without penicillin was 14.7 per cent as compared to 9.3 per cent after penicillin was available. However, one cannot get away from the fact that early and adequate surgery cannot be replaced by drug therapy.

Ideally, water-tight closure of cranial wounds is desirable in order to prevent cerebrospinal fluid leaks. This is particularly true if the ventricle has been opened and in those cases where the wound is near the base of the skull in the neighborhood of one of the cisterns. A postoperative cerebrospinal fluid leak occurred in two cases. In one, the lateral ventricle ruptured spontaneously after the tract had been followed down to the wall of the ventricle where the metallic foreign body was found. The dura was closed with silk under tension as was the scalp. In retrospect, closure of the dura by fascial transplant and a more extensive plastic repair of the scalp wound to avoid tension might well have prevented this disturbing complication. The other instance of cerebrospinal fluid leakage was the case of ventriculitis referred to above.

Jacksonian convulsions rarely occur in the early postoperative course following brain wounds; however, when present, they are

of special significance and point to local difficulty.[4] Such seizures were encountered three times in a series of 107 operative cases. The seizures were due to an abscess in the brain tract in one instance, an epidural hematoma in another, and still another was due to a superficial wound infection. In the latter case, the dura had been closed by a temporal fascia transplant which remained in situ in the presence of an open wound and the infection did not extend intracranially. In all three instances the convulsions ceased following appropriate therapy. The postoperative hematoma serves to emphasize the dire necessity of absolute hemostasis before the wound is closed.

Wound dehiscense may be avoided by closure without tension. The time required to carry out plastic procedures on the scalp in order to obtain firm closure is well worth while. In one of our cases wound separation occurred due to closure of a tripod incision under tension. Too much tension may be said to exist when the galea cannot be approximated with ease by interrupted sutures of fine silk.

Pulmonary complications are most apt to occur in stuporous patients. To avoid such complications, frequent turning and aspiration of the tracheal tree is desirable. One of the deaths was due to bilateral bronchopneumonia with multiple small pulmonary abscesses. This patient had a large parasagittal wound with bone fragments embedded in the corpus callosum. He remained comatose for five days and stuporous thereafter until death on the fourteenth postoperative day. Signs of bilateral pulmonary consolidation were present during the last week of life.

Two cases developed parotitis. Both occurred in spite of active chemotherapy. These examples emphasize the importance of mouth care in those who are unable to help themselves.

Summary

1. The incidence and mortality rate of penetrating wounds of the brain is discussed.

2. Preoperative examination and care, operative technic and postoperative care of brain wounds are presented.

3. The value of chemotherapeutic drugs in treating brain wounds is reviewed.

4. The early postoperative complications encountered in 107 penetrating wounds of the brain are presented.

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THE SMALL COMMUNITY HOSPITAL

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For many years hospital facilities have been well developed in our larger towns and cities. This condition was brought about by the fact that all facilities for enjoying and prolonging life were more effectively and thoroughly organized in the larger centers of population. These hospitals and medical facilities served not only their own people, but also many from the suburban and surrounding rural districts, frequently from a distance of two hundred miles or more.

Around the turn of the century medical schools were graduating a large number of students, many of whom entered immediately upon general practice without postgraduate study pointing to a specialty, usually in rural or small urban areas.

Within the past fifteen to twenty years there has been a definite trend among recent graduates to prepare themselves for a specialty and stay in the larger urban centers. There has been a corresponding decrease in the number of general practitioners who are willing to work in small communities and rural areas. There are many factors responsible for these changes.

Because of the trend in medical education toward specialization and a consequent shift of physicians from rural to metropolitan areas, we find ourselves now faced with an appalling scarcity of medical servants outside the larger centers throughout the United States, especially in the South and West, where now patients actually suffer from lack of medical care.

There are those who feel that this condition is largely due to a dislocation of physicians incident to military service in the recent war, but I am prepared to show you that this tendency has existed for several years.

In 1912, with a population of 28,000, Muhlenberg County, Kentucky, had 50 active general practitioners, but in 1946, with a population of 38,000, there are only 9 physicians, 6 doing general practice exclusively, 1 E. N. T., and 2 who do general surgery with a minimum of general practice. The average age of this group is 59.6 years, 3 men under 60 and 2 over 70. The Commissioner of Health in the State of Kentucky compiled the following data corrected to Dec. 12, 1945, and applying to each of Kentucky's 120 Counties. Total population 1940 census, total number of physicians in active practice, total active physicians over 60 years of age, and a ratio of patients to physicians, which is shown by the following Table:

County	1940 Pop.	Total M. D.'s Active Practice	Total Active M. D.'s Over 60 Yrs. of Age	Persons Per M. D.	M. D.'s Still in Military Service
1. Adair	18,566	6	4	3,094	
2. Allen	15,496	4	1	3,874	1
3. Anderson	8,936	7	5	1,277	
4. Ballard	9,480	6	3	1,580	1
5. Barren	27,559	15	7	1,837	7
6. Bath	11,451	7	4	1,636	
7. Bell	43,812	28	8	1,550	7
8. Boone	10,820	9	4	1,202	2
9. Bourbon	17,932	14	5	1,281	2
10. Boyd	45,938	31	14	1,482	13
11. Boyle	17,075	17	11	1,004	3
12. Bracken	9,389	8	3	1,174	3
13. Breathitt	23,946	2	1	11,973	1
14. Breckinridge	17,744	5	2	3,548	1
15. Bullitt	9,511	3	1	3,170	
16. Butler	14,371	2	1	7,185	
17. Caldwell	14,499	7	4	2,071	3
18. Calloway	19,041	11	4	1,731	4
19. Campbell	71,918	45	16	1,598	15
20. Carlisle	7,650	3	1	2,550	
21. Carroll	8,657	5	2	1,731	1
22. Carter	25,545	10	7	2,554	1
23. Casey	19,962	4	2	4,995	
24. Christian	36,129	23	14	1,571	9
25. Clark	17,988	14	9	1,285	4
26. Clay	23,901	2	1	11,950	
27. Clinton	10,279	6	2	1,716	1
28. Crittenden	12,115	5	3	2,423	
29. Cumberland	11,923	3	2	3,974	
30. Daviess	52,335	39	20	1,342	6
31. Edmonson	11,344	1		11,344	1
32. Elliott	8,713	1	1	8,713	
33. Estill	17,978	5	3	3,595	1
34. Fayette	78,899	101	33	781	36
35. Fleming	13,327	9	5	1,481	2
36. Floyd	52,986	28	9	1,891	5
37. Franklin	23,308	15	7	1,554	6
38. Fulton	15,413	12	6	1,284	3
39. Gallatin	4,307	1		4,307	
40. Garrard	11,910	6	3	1,985	

County	1940 Pop.	Total M. D.'s Active Practice	Total Active M. D.'s Over 60 Yrs. of Age	Persons Per M. D.	M. D.'s Still in Military Service
41. Grant	9,876	5	3	1,976	2
42. Graves	31,763	18	11	1,765	3
43. Grayson	17,562	8	8	2,195	
44. Green	12,321	5	3	2,464	
45. Greenup	24,917	8	4	3,115	
46. Hancock	6,807	2	2	3,404	
47. Hardin	29,108	16	9	1,819	1
48. Harlan	75,275	40	8	1,882	16
49. Harrison	15,124	13	8	1,163	2
50. Hart	17,239	7	3	2,463	1
51. Henderson	27,020	21	13	1,287	1
52. Henry	12,220	15	12	815	1
53. Hickman	9,142	3	2	3,047	1
54. Hopkins	37,789	21	18	1,799	1
55. Jackson	16,339	3	3	5,446	
56. Jefferson	385,392	450	164	856	215
57. Jessamine	12,174	9	4	1,353	2
58. Johnson	25,771	13	6	1,982	4
59. Kenton	93,139	64	18	1,455	19
60. Knott	20,007	2	2	10,004	
61. Knox	31,029	7	4	4,433	2
62. Larue	9,622	5	3	1,524	
63. Laurel	25,640	5	3	5,123	1
64. Lawrence	17,275	6	4	2,876	1
65. Lee	10,860	4	3	2,715	1
66. Leslie	14,981	2	1	7,490	1
67. Letcher	40,592	15	3	2,706	7
68. Lewis	15,686	4	2	3,916	
69. Lincoln	19,859	6	4	3,309	2
70. Livingston	9,127	5	4	1,825	1
71. Logan	23,345	10	7	2,335	2
72. Lyon	9,067	3	2	3,022	
73. McCracken	48,534	42	25	1,155	4
74. McCrary	16,451	4	1	4,113	1
75. McLean	11,446	7	5	1,635	
76. Madison	28,541	31	13	920	8
77. Magoffin	17,490	4	3	4,372	
78. Marion	16,913	7	2	2,416	1
79. Marshall	16,602	9	9	1,845	2
80. Martin	10,970			10,970	

County	1940 Pop.	Total M. D.'s Active Practice	Total Active M. D.'s Over 60 Yrs. of Age	Persons Per M. D.	M. D.'s Still in Military Service
81. Mason	19,066	13	8	1,466	3
82. Meade	8,827	1	1	8,827	2
83. Menifee	5,691	1	1	5,691	
84. Mercer	14,629	10	4	1,463	5
85. Metcalfe	10,853	4	3	2,713	
86. Monroe	14,070	7	4	2,010	
87. Montgomery	12,280	10	6	1,228	1
88. Morgan	16,827	4	3	4,207	3
89. Muhlenberg	37,554	9	6	4,173	2
90. Nelson	18,004	10	7	1,800	2
91. Nicholas	8,617	4	4	2,154	
92. Ohio	24,421	7	5	3,488	3
93. Oldham	10,716	5	2	2,143	
94. Owen	10,942	5	4	2,188	1
95. Owsley	8,957	2	1	4,478	
96. Pendleton	10,392	5	3	2,078	
97. Perry	47,828	27	8	1,772	7
98. Pike	71,122	25	9	2,845	8
99. Powell	7,671	3	3	2,557	
100. Pulaski	39,863	23	13	1,733	1
101. Robertson	3,419	2		1,709	
102. Rockcastle	17,165	6	5	2,861	
103. Rowan	12,734	2		6,367	1
104. Russell	13,615	4	2	3,404	2
105. Scott	14,314	13	11	1,101	3
106. Shelby	17,759	12	7	1,480	2
107. Simpson	11,752	8	5	1,469	2
108. Spencer	6,757	4	3	1,689	
109. Taylor	13,556	7	3	1,937	1
110. Todd	14,234	5	3	2,847	
111. Trigg	12,784	5	2	2,557	1
112. Trimble	5,601	1		5,601	1
113. Union	17,411	11	8	1,583	1
114. Warren	36,631	27	12	1,357	5
115. Washington	12,965	3	1	4,322	2
116. Wayne	17,204	4	1	4,301	1
117. Webster	19,198	13	8	1,477	
118. Whitey	33,186	19	8	1,746	4
119. Wolfe	9,997	2	2	4,998	
120. Woodford	11,847	8	4	1,401	
Totals	2,845,627	1,749	817	1,627	506

These data point out conclusively to you that in the counties in which the larger metropolitan areas are located, especially Fayette and Jefferson Counties, there is a small ratio of patients per physician, namely 781 and 856 respectively; whereas in the average for the entire state there are about 1,627 patients per physician.

What can be done to correct this faulty distribution of physicians? Citizens in our rural areas have the same illnesses as do the more fortunate city-dwellers—fortunate so far as medical service is concerned, at least—have a similar, or higher, death rate; deserve and must have some program prepared which will place at their disposal adequate and well trained medical personnel.

Shall we expect the general men in the field to serve longer hours and by so doing see more patients each day? No, indeed! Many men now doing full time work would in ordinary times be retired; many others should curtail their activities in order to secure more relaxation—no small number have actually developed coronary disease and other exhaustive illnesses because of undue exertion from long and arduous hours of service to a deserving clientele.

There is much to be said in favor of a program to encourage a voluntary even distribution of physicians throughout our population. A factor to be considered is improvement of the rural community, making it more attractive from the standpoint of educational facilities; religious, social and cultural programs; surfacing of secondary and farm-to-market roads, rural electrification, soil conservation, etc.

Something should also be done to swell the ranks of the rapidly disappearing general practitioner. Most rural and small urban physicians are so called general practitioners or family physicians and rightly so. A few have a specialty and also do some general practice, which is permissible and commendable. There is a feeling that since much publicity has been given the specialist in various fields, the eminent and extremely important place occupied by the general practitioner has suffered in prestige and respect in the minds of the public, and also in the minds of the students, interns and young practitioners. Some feel that if a man is not qualified scholastically for a specialty he can always do general practice in the country. This reasoning is not only false but is illogical. In rural areas where consultants are not readily accessible the practitioner comes face to face with many and diverse pathologic conditions, and his judgment determines to a large degree the final results in treating these illnesses. Too often the decision is his and his alone; therefore, these men should be well

qualified by reason of sound training. Medical schools and the organized profession itself could assist in accomplishing these ends: the schools by recognizing the importance of the general practitioner and including the proper courses of instruction in their curriculum; the organized profession by creating sections on general practice in the various national organizations. Student loan funds are instrumental in encouraging rural practice. Such programs are in effect in Georgia, Alabama and Virginia. Kentucky has a modest student loan fund which is functioning at the present, and before the General Assembly, now in session, there is a bill requesting a fund to provide two medical scholarships of $800.00 annually for each of nine congressional districts. These young men and women are to be required, among other considerations, to practice in rural Kentucky for a period of from two to five years.

But nothing would stimulate a decentralization of physicians as much as would an intelligent and thorough program for establishing facilities for modern medical practice in the outlying districts. Health units, preventative and educational in nature, maternity centers in small communities where needed, but most important of all the establishment of the small community hospital around which an excellent medical group could be assembled.

It is too much to expect the profession to establish such facilities, since in many instances sufficient means are not available to them and after all such responsibility rests with the community at large, much the same as does the establishing of schools and churches. The hospital should be community-owned and fostered by a fine community spirit. There is increasing evidence that the desirability of such a movement is recognized by many individuals and groups, both lay and professional, in our country. As a matter of fact, the U. S. P. H. S. is at present making an exhaustive study through a Federal grant, of all existing hospital facilities throughout the entire nation, in anticipation of Governmental assistance to the various communities who need to establish facilities to care for the ill. These funds will probably be allocated upon a basis of existing facilities and also upon the ability of the interested community to provide funds to complement those furnished by the Government. There is legislation now in Congress to provide funds for these projects, originally introduced as the Hill-Burton Bill and providing for Federal grants to local groups on a ratio of from 25 to 75 per cent Federal aid.

No community should have more hospital beds than it could reasonably and efficiently use. The size of the unit should be based upon the population served. Many think that the mini-

mum should be 100 beds; be general in scope; be organized as to departments; be required to observe and comply with accepted standards of construction and also with the minimal professional standards of quality as prescribed by the American College of Surgeons, including complete records, histories, physical findings, operative and treatment notes, progress, consultation and dismissal notes, complete laboratory facilities, including x-ray and tissue study, etc. The nursing staff should meet the minimal standards; the medical staff should be well organized and members required to adhere to their respective fields. It would be possible that some of the specialties could be advantageously combined in the small units: obstetrics and pediatrics, E. N. T. and allergy, general and gynecologic surgery; orthopedics and urology, etc. It might also be possible that an individual doing a specialty might also have to see in his office some general patients; occasionally house calls would also have to be made, unless there are enough men in the community doing general practice to take care of these conditions.

Group practice should be encouraged in these communities, thereby establishing pools of consultants accessible when needed. These community hospitals will not only improve the quality of medical practice in the community by attracting more thoroughly trained men, but will also improve it by creating facilities, principally laboratory and nursing service, which will be available to the general men already in the given area. Clinical experiences as a result of these privileges are stimulating and broadening medically and add to the professional efficiency and personal pleasure of a group of worthy and often unappreciated public servants.

Some will be skeptical of the small community hospital being able to remain solvent, especially in times of great economic stress such as we experienced in this country in the early 30's, and justly so perhaps. However, it seems logical that provisions could be made, Federal if necessary, to care for hospital expenses of the indigent in the small rural areas similar to those by which they are now provided for in cities and larger towns, namely, by public taxation.

Others will contend that the quality of medical care in the small hospital will always remain below that in its larger counterpart and that surgery and serious medical illnesses should be transported to the cities. Many others, and among these many intelligent lay individuals, feel that such customs are quite antiquated and that, given a physical plant with adequate equipment, the medical care found in any community, large or small, will vary

directly with the quality of medical personnel available to make use of such facilities.

Conclusion

There has been a decrease in the number of medical personnel serving rural communities because of: (1) better general living conditions in larger towns and cities; (2) a trend to medical specialization, with a decrease in the number of the important general practitioners; (3) the lack of stimulating associates and hospital facilities in the rural community.

These conditions could be improved by: (1) the small centers making their communities more attractive; (2) correcting overspecialization by educating the public and the undergraduate to a more favorable understanding of the value of the general practitioner; (3) encourage group practice; (4) creating such facilities as county health units, maternity centers and small community hospitals.

GRAFT SUBSTITUTION OF LONG BONE SHAFT DEFECTS

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The observation of extremity injuries during this war has offered unparalleled opportunities for the study of bone shaft defects. High speed penetrating missiles often blasted out large sections of diaphysis without disturbing joints. Modern surgical care administered early enabled most of these patients to survive such extremity injuries and to be evacuated to general hospitals in this country for eventual attempts at reconstruction rather than amputation. In some instances, an overzealous debridement of a compound fracture with removal of all loose bone fragments also resulted in a complete absence of a section of shaft. Suggestions as to the method of surgical reconstruction to be employed in such cases are extremely few in the available literature.

There is no claim of originality of the methods used by the authors in the following cases. The cases are reported as they were handled by an orthopedic group in one general hospital using methods which in principle have been previously presented by other authors. Possibly another method would have served equally as well, or better, in most of them.

This presentation deals only with surgical technics. Supportive treatment, such as the use of penicillin, sulfonamides, plasma, etc., has been adequately covered in numerous publications since the onset of the War. Suffice it to say that our patients received full advantage of these aids preoperatively and postoperatively.

Tibia

The first defect problem to confront us was that of the tibia. The fibula was always intact and in those where it too had been fractured, fibular bone healing had occurred in all except one. This patient had a non-union of the middle third of his fibula in addition to the tibial defect. Draining sinuses and severe scarring at the anterior wound site were present in every case. If the roentgenogram showed sequestrae formation a clean-up operation for their removal plus the excision of infected granulation tissue

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was done. Some healed completely following such a procedure. If scarring was considered sufficiently severe to jeopardize future grafting procedures, the next step was to excise scar tissue and substitute appropriate healthy skin covering, preferably by the

Fig. 1. Shaft defect of tibia.

pedicle flap or tube method. After having remained healed for three to four months, cortical onlay grafts from the opposite tibia were applied to the lateral and medial aspects of the proximal and distal fragments in such a manner as to bridge the defect and fastened with through and through metal screws. As much cancellous bone as could be obtained was placed in the central cavity. Four to six months of fixation in a long leg plaster cast was found to be necessary before sufficient union for weight bearing occurred.

In fourteen cases in which drainage persisted, another method of approach was used. The fibular shaft was grafted to the tibial fragments in two stages, the proximal end to the proximal fragment, and after union had occurred, the distal end to the distal fragment. In the first of these patients so treated, the fibula united solidly with the tibial fragments at both ends, the tibial

fragment stumps united with the fibular shaft and the mid-section of the fibula underwent sufficient hypertrophy to compensate for the missing fragment of tibia, making further grafting procedures unnecessary. Removal of the two distal screws was done because of drainage and following this all sinuses promptly healed. This patient was bearing full weight on this leg without

Fig. 2. Fibular hypertrophy after transplantation.

external support eighteen months after the second stage of the fibular transplant was performed.

In other cases, supplementary grafts from the opposite tibia were necessary later because the transplanted fibula did not undergo sufficient hypertrophy as it did in this first case.

It was concluded by the authors that early fibular transplant is indicated in all such cases as a fibular transplant reestablishes blood supply to the distal tibial fragment. This helps to prevent the process of bone atrophy resulting from loss of the nutrient vessel. When supplementary grafts are added, their successful "take," particularly to the distal tibial fragment, has a greater chance of success because of this reinforced blood supply. The technic of the application of these later grafts is simplified by

having viable instead of brittle bone with which to work. Lastly, the possibility of fibular hypertrophy sufficient to compensate for the tibial loss without the necessity of further grafting procedures is always present. Using this technic, a surgeon may proceed with definitive treatment months sooner than with more orthodox methods despite drainage at the site of injury.

Fig. 3. Tibial onlay grafts and fibular transplantation for loss of tibial shaft substance.

Metatarsal

Foot injuries with loss of substance of a metatarsal shaft have been less frequent than leg injuries. Most of those we have seen had the second, third, or fourth metatarsal shafts involved singly or in combination. One patient had lost the mid-portion of his first metatarsal, and he was treated by using an inlay substitution graft of tibial cortex. Union occurred with minimal deformity.

Another patient with a section of the third metatarsal missing was having persistent severe pain on weight bearing. He was treated by the application of an intramedullary tibial cortical

peg. It could not be determined whether satisfactory union had occurred in a roentgenogram six months later but he had no more pain and he was placed on general military duty at his own request.

The other patients in this category were treated without operation and walked well using a rigid metal combination longitudinal and metatarsal support inserted in their shoe.

We conclude that most patients with loss of shaft substance of metatarsals other than the first metatarsal, should be treated in this conservative manner rather than by operation as they usually

Fig. 4. Femur shaft defect.

are able to walk with, at the most, only minimal discomfort. This is probably true because of the rigid fixation of the entire shaft of these metatarsals by strong ligaments and fascia normally present.

Femur

Femoral shaft substitution has been a tremendous problem in our hands because of the obvious difficulty in adults of obtaining sufficient bone from other autogenous sources to make up for the large volume of bone lost. We have operated on four cases. One was a matter of adding tibial cortical onlay and inlay grafts and cancellous bone to supplement a small amount of cortical union already bridging the gap in the distal third. We are

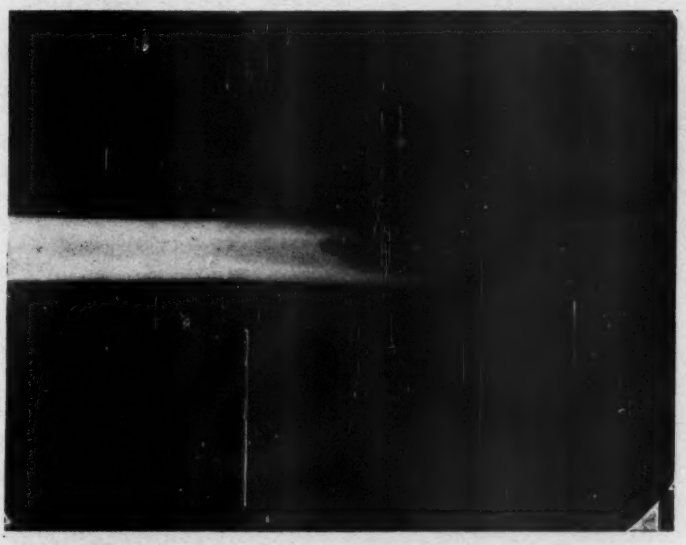

Fig. 5. A-P view of femur defect filled in with onlay tibial grafts and iliac bone.

Fig. 6. Lateral view of closed femur defect area after union of grafts.

satisfied that this procedure shortened convalescence by months and possibly years.

The other three cases had complete absence of sections of shaft and they were treated with preliminary skeletal traction to restore the length of the extremity. At operation, bridging dual cortical tibial grafts, one obtained from one tibia and one from the other, were applied and fastened to each fragment with through and through metal screws. Cancellous bone from the tibiae and the ilium was packed into the central cavity. The skeletal traction was maintained during the operation. Following operation the first of these cases was placed in a double spica cast. The second was treated similarly and after three weeks, the bridging grafts were found to be angulated. The cast was removed and balanced skeletal traction with a Kirschner wire through the proximal end of the shaft of the tibia was employed with the leg cradled in an army half ring splint and Pearson attachment. This restored alignment and length. Fearing the same situation might have occurred in the first patient, his cast was removed and, though a roentgenogram showed good position, traction by the same method was applied.

The third patient was treated with continuous traction before, during and following operation.

Union occurred in the first two of these cases but had not occurred in the last case eleven weeks postoperatively when he was transferred elsewhere with his traction maintained. At the time of our last observation, he had a local infection and was draining from several sinuses at the operative site.

We concluded that traction instead of cast fixation should be employed postoperatively in femoral shaft substitution cases to offset the tremendous pull of the strong musculature of the thigh and hip which can cause deformity even in the presence of internal and external fixation. This concept has also proven true in the treatment of the majority of femoral fractures.

Three other femoral shaft defects also came under our observation, two of which were not considered ready for surgery at the time of our transfer elsewhere and the other was transferred to an amputation center because we felt that his condition did not warrant reconstruction.

Metacarpal

Only a few patients with metacarpal shaft substance loss were treated as most such patients have been sent directly to plastic centers from overseas. The majority of cases seen on our service had such extensive involvement of skin, tendons and joints along with the shaft defect that, due to current directives from the Surgeon General's Office, they were transferred to plastic centers.

Two patients with middle metacarpal shaft defects were operated on. Intramedullary tibial cortical peg grafts were used. The grafts united in both instances after six weeks of cast fixation. Although there was some shortening of these metacarpals, better functioning hands resulted.

The authors believe that transverse skin incisions on the dorsum of the hand should be used in such operations as transverse incisions are less conducive to cicatrix formation and adhesions to deeper structures than are longitudinal incisions.

Humerus

Only one patient with a complete loss of a portion of his humerus was observed; in this instance the entire proximal half of the bone was absent. The elbow, forearm and hand were remarkably preserved without nerve involvement and with perfect active and passive motion. The strength of the hand and forearm was excellent. Since the soft parts of the shoulder presented such a tremendous plastic problem, which should properly be attacked preliminary to the reconstruction of the bone, he was transferred to a plastic center.

Another patient had a partial loss of substance and a non-union in the distal third of the shaft of his humerus. Dual onlay tibial cortical grafts were applied and fastened to the fragments with metal screws. In this area, such grafts are not as difficult to place on the anterior and posterior surfaces of the bone as they would be on the thin lateral aspects and opposition of the grafts to the shaft when so placed provides a wider area of bone contact. At the time of his transfer elsewhere two months later, union was not complete and he was still in an airplane spica cast.

It is interesting to note that on this service during a two year period, only two non-unions of simple fractures of the proximal two-thirds of the humeral shaft were seen out of approximately 240 cases. These two patients had been treated from the time of first reduction in airplane spica casts. No non-union has yet been observed in any case in which a hanging cast was applied at the onset of treatment.

Ulna and Radius

Long bone shaft loss in the forearm can be a very serious disability to an individual from an economic viewpoint. Such problems have been relatively frequent on this service. We have performed sixteen substitution grafts, nine on the radius and seven on the ulna in two years. Two of these patients had only small

Fig. 7. Ulnar shaft substance loss.

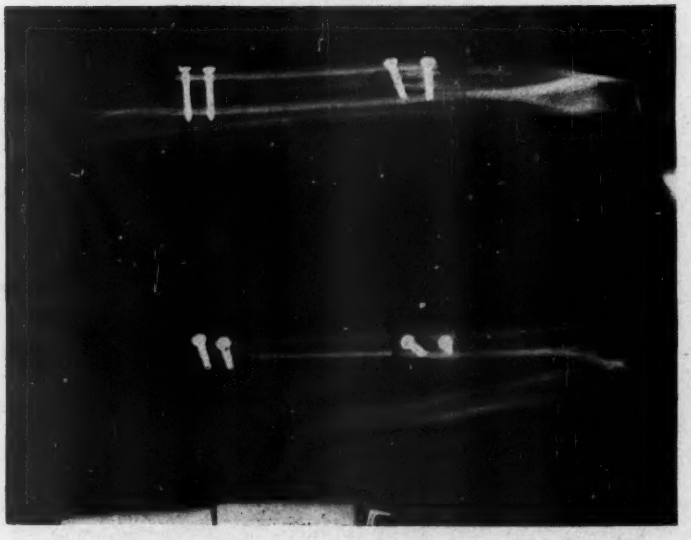

Fig. 8. Replacement of ulnar shaft loss with fibular step-cut graft.

sections of the distal third of the radius missing with shortening of the bone and posterior dislocation of the distal end of the ulna.

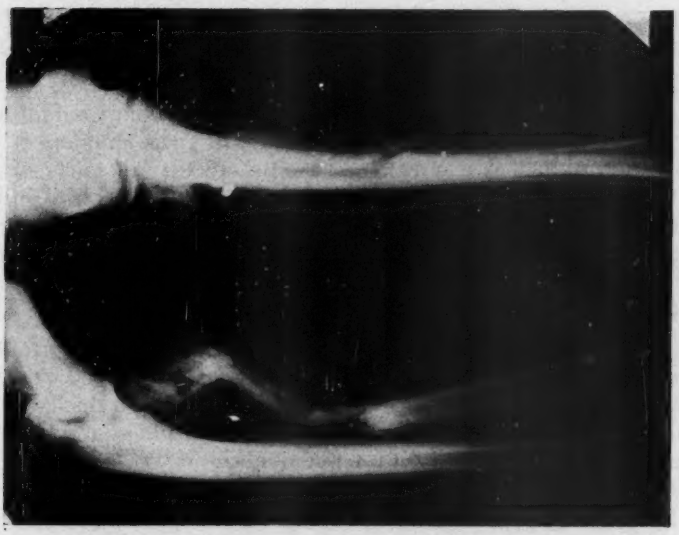

Fig. 9. Radial shaft fracture with mal-union.

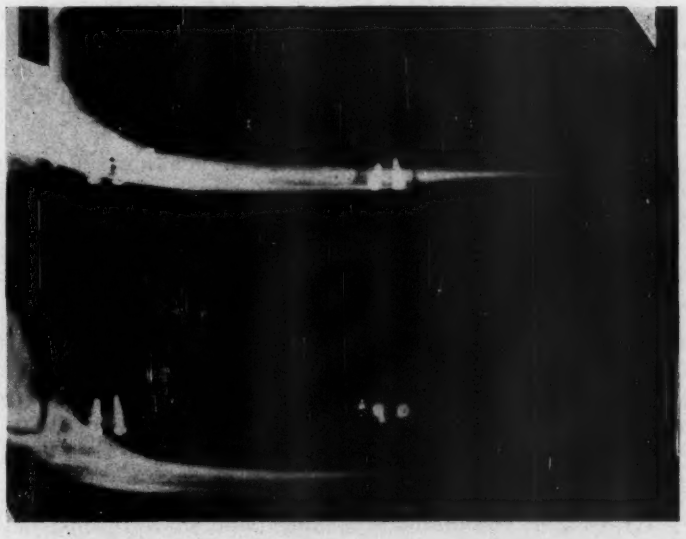

Fig. 10. Replacement of malunited radial shaft with fibular step-cut graft.

They were treated by the application of tibial cortical onlay grafts fastened to the freshened dorsal surfaces of the radial fragments

with metal screws, and resection of the distal end of the ulna. Both obtained excellent cosmetic and functional results after several months.

In the patients with more extensive forearm bone shaft losses, the fibular step-cut, or notched-end, graft was employed. It has been applied as a substitute for practically all parts of the shafts of both ulna and radius and seems universally to result in union in any locality. Six inch substitution which requires an 8 inch section of fibula has been used successfully and we would not hesitate to use even longer sections with good chance of a "take" in a case requiring such a graft.

Union and improvement in appearance and in function of the extremity has occurred in nine of our cases so treated and the remainder appeared to be well on the road to a good result at the time of last observation with one exception. This patient had a postoperative infection with osteomyelitic involvement of the proximal end of his fibular transplant and the stump of the radius to which it was fastened. Some absorption had occurred four months after the operation but it is hoped that prolonged plaster fixation will result in at least a delayed union or a non-union without extensive loss of bone.

Another one of these patients has a draining sinus on the forearm, presumably originating at the site of a screw through the distal end of the fibula section and the ulna stump, but union has begun. Removal of the screw after complete union may result in complete subsidence of the infection.

Before closing, we wish to emphasize the fact that the removal of superficial and deep scars and the substitution of healthy skin and soft tissue covering as a preliminary measure, is mandatory for the success of the majority of these bone reconstruction procedures.

This paper has been presented with the hope that it will stimulate groups at other hospitals to report similar cases with the methods of reconstruction used. This is the only sound manner in which more standardized recommendations can ever be formulated for the successful treatment of bone shaft defects.

Summary

1. A review of the methods of long bone shaft reconstruction by substitution grafts as done in an Army General Hospital is presented.

2. Early fibular transplant graft to the tibial fragments following loss of tibial shaft substance is advocated.

3. Postoperative skeletal traction in femoral section substitution graft cases, instead of plaster fixation, is advised.

4. Fibular step-cut grafts as substitution for missing sections of ulnar and radial shafts are favored.

CONTINUOUS SPINAL ANALGESIA AND ANESTHESIA IN SURGERY, OBSTETRICS AND THERAPEUTICS

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Memphis, Tenn.

Less than sixty years ago A. J. Corning of New York City unintentionally used spinal anesthesia in the treatment of a sexual neurosis. Dr. Corning first injected cocaine into the subarachnoid space of a dog in an experiment to determine the technic for epidural injections. The animal survived the experiment and Corning was encouraged to use spinal anesthesia in 1888 in a male patient in an attempt to interrupt the pernicious neuroreflexes stimulating chronic masturbation. This was one year before Quincke described his technic for lumbar puncture. In 1898 August Bier, after first having his own subarachnoid space injected with 20 milligrams of cocaine, introduced to the medical profession a successful clinical technic of spinal anesthesia in surgery. In 1899 Dr. Rudolph Matas of New Orleans first employed spinal anesthesia for surgery in the United States. In the same year Dr. Samuel Johnson of Toronto first introduced this method in Canada. In 1900 Kreis of Germany introduced spinal anesthesia in obstetrics. In 1905 Einhorn of Germany synthesized and introduced novacaine as a replacement for the more toxic cocaine. During the next 20 years spinal anesthesia was used and abused throughout the world. The medical profession first praised, and then condemned, this method of pain relief as the rising total of spinal anesthesia deaths were reported in medical meetings and in medical literature. In 1921 when Gaston Labat established a Department of Anesthesia at the Mayo Clinic only one spinal anesthetic was administered for the entire year. This single administration was in marked contrast to the 11,000 spinal anesthetics administered in the same clinic in 1944. Thus in two decades physicians learned the safe use of spinal anesthesia from the great American teachers, Wayne Babcock of Philadelphia, George Pitkin of New Jersey, Louis Maxson of Washington state, and George Vehrs of Oregon. The introduction of the longer-acting pontocaine in 1927 and metycaine in 1926 extended the use of spinal anesthesia. In 1930 Cosgrove of the Margaret Hague Maternity Hospital reported the first large series of cases in obstetrics delivered under spinal anesthesia. This technic, using a smaller dosage of 75 to 100 milligrams of procaine in the second stage of labor replaced the more dangerous technic of Pitkin, who advocated the use of 400 milligrams of procaine as a single dose

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injected with glucose to produce saddle-block anesthesia. DeLee, recognizing the hazards of spinal anesthesia in obstetrics as then administered, rightly became the leading opponent of a method in vigorously condemning its use in obstetrics. The echo of this condemnation is today emphatically reverberated by Greenhill.

The purposes of this paper are: (1) to point out the recent advances and improvements in technic; (2) to emphasize the application of principles of physiology in safeguarding patients managed with this technic; (3) to challenge the prejudiced and uninformed opposition to spinal anesthesia, to reevaluate this method for their own use, or else to deflate their condemnation by scientific fact.

Continuous Spinal Anesthesia

Early in 1939 William T. Lemmon of Philadelphia conceived the idea of continuous spinal anesthesia. A method of administering serial doses through a malleable in-dwelling needle was formulated and used on experimental animals: dogs, rabbits and monkeys. It worked. The application of this method in the practice of surgery has been a milestone in surgical progress of this century. To implement and facilitate this technic, a divided sponge rubber mattress was built. This mattress contains an opening through which the needle may be adjusted to provide and maintain a "middle-of-the-stream" subarachnoid puncture. This is evidenced by the ability to aspirate spinal fluid at any time. This method provides for the first time finger-tip control of the anesthetic. It greatly diminishes the possibility of over-dosage. It reduces to a minimum the number of cases in which spinal anesthesia will wear off in prolonged operations. It permits the administration of safe minimum doses in the debilitated, the aged, in children, for cesarian section, and obstetric delivery, where not only the mother, but also the unborn baby, must be protected from profound pharmacologic effect.

By August, 1944, Lemmon was able to report his observations on 2000 cases in which continuous spinal anesthesia was used in surgery. In November, 1945, Hinebaugh and Lang were able to report their results in 300 cases without maternal mortality for obstetric delivery.

In July, 1944, J. C. Ullery of Philadelphia was able to report its use in 308 cases in obstetrics and gynecology. During the past two years Ullery and I have used continuous spinal anesthesia in 295 cases for cesarian section. In this group there was not a single maternal death, and there was a great salvage of fetal life.

In the John Gaston Hospital and in the other hospitals of Memphis, we have used continuous spinal analgesia in an additional 58 cases in cesarian section, gynecology, and obstetric delivery, without severe complication.

The use of the malleable, stainless steel continuous caudal analgesia hubless needle has been a distinct advance in the development of continuous spinal anesthesia.

In 1944 Edward Tuohy conceived the idea of continuous spinal analgesia and anesthesia instituted through a ureteral catheter that is placed within the subarachnoid space through a directional 16-gauge needle. This refinement in technic has eliminated the necessity for the special mattress used by the other investigators. This method is now being evaluated. Even though it is slightly more difficult from a technical standpoint, it greatly extends the use of this method for prolonged surgery; for prolonged therapeutic control of hypertension; for the control of pain and the removal of angiospasm, in peripheral vascular disease, and angiospastic nephritis with anuria.

In surgery it has its greatest usefulness in providing pain relief and abdominal relaxation for operations on the stomach, spleen and liver. It is also a very practical technic as an anesthetic for bilateral hernioplasty, and plastic operations within the pelvis and perineum. Average inductions and initial doses for these operations are: Procaine, 75 to 100 milligrams; metycaine, 50 to 75 milligrams; pontocaine, 10 to 12 milligrams. The short-acting local anesthetics, procaine and metycaine, provide surgical anesthesia for these cases from 30 minutes to one hour. When pontocaine is used, the initial dose frequently lasts one hour to one hour and a half or two hours. Supplementary doses *pro re nata* average as follows: Procaine, 25 to 50 milligrams; metycaine, 15 to 45 milligrams; pontocaine, 8 milligrams. For upper abdominal and thoracic operations the optimum nerve block with maximum safety may be achieved with the needle inserted between the first and second lumbar spines, or between the 12th thoracic and the first lumbar. For lower abdominal, pelvic, and lower extremity surgery, it is wise to enter the subarachnoid space between the lower lumbar spines. Neither Doctor Lemmon nor I recommends barbitage of the anesthetic agent. It is my own practice to administer these anesthetic agents in a vehicle of physiologic Ringer's solution of 1.5 to 2.5 per cent strength for the short-acting agents, and a .15 to .25 per cent for pontocaine. The abandonment of metycaine by the Army was unwarranted and unjustified in light of scientific appraisal of its efficient, safe performance in the hands of the doctor who understands its pharmacologic action.

In Obstetrics

There is no method of pain relief in obstetrics which is as prompt and as complete as that provided by continuous spinal anesthesia and analgesia. However, certain warnings should be emphasized concerning the use of this method here. The subarachnoid pressure of a pregnant woman, and particularly one in labor, presents a picture of turbulent oscillation, synchronous with uterine contraction, bearing-down efforts, and position-change. Since analgesia, or relief from pain only, is required in obstetrics, it is possible to obtain perfect results with almost unbelievably small doses. Through injections via the first lumbar interspace we are able to secure prompt surcease from labor pain within 30 seconds to one minute with 15 milligrams of metycaine, and 25 milligrams of procaine. The parturient woman should remain on her side until the descent of the presenting part into the pelvis has reached a maximum and delivery is imminent. At this time the patient may be turned into the lithotomy position. A repeat dosage of 1 c. c., or 15 to 25 milligrams, of short-acting anesthetic agents may be administered *pro re nata* on an average of each 30 minutes to one hour.

In our experience the use of continuous spinal analgesia for obstetric delivery is most successfully carried out during the last one or two hours of labor. Too early inductions, or too large a dose, will retard the forces of labor. A human mother at term weighs 55,000,000,000 milligrams. With 15 to 25 milligrams of the anesthetic agent deposited within a closed space, total pain relief is achieved without possible narcotization of the baby. The only danger to the baby is that of anoxia, which might develop during inexpert management of a parturient whose systolic blood pressure is allowed to fall to hypotensive levels below 90 to 80 millimeters of mercury.

For cesarian section the average patient is prepared with an initial dose of 2 c. c. of 1.5 per cent metycaine, containing 30 milligrams, or 2 c. c. of 2 per cent procaine, containing 40 milligrams. In the great majority of patients nerve block is achieved with this technic to the costal margin. Rarely a supplementary dose of 1 to 2 c. c. is required for refractory cases, or in cases operated upon by the slow or meticulous surgeon.

Therapeutics

In therapeutics also this method has an important place. Some of these useful applications are as follows: (1) as a therapeutic test predicting the value of surgical sympathectomy in hypertension; (2) to release angiospastic elements which aggravate and

accentuate peripheral vascular disease, such as Buerger's thromboangiitis obliterans, immersion foot, trench foot, frost-bite, causalgia, pre-gangrenous and gangrenous states of diabetes, and arteriosclerosis. From our experience it is my opinion that no patient should have an amputation of an extremity on the basis of anoxischemia until it has been demonstrated by two hours of continuous spinal analgesia that adequate blood supply is impossible. So often with the use of this method dark blue extremities become pink, warm and dry as the delicate non-myelinated sympathetic fibers are blocked along with the fibers transmitting pain. With small dosage of 15 to 30 milligrams of a short-acting local anesthetic placed within the subarachnoid space with expert precision in regard to the specific somatic segmental innervation it is possible to maintain a degree of motor and proprioceptive activity. Before the advent of continuous spinal analgesia I reported a personal series of more than 5,000 single-injection spinal anesthetics. Since this advance has been made, I am now able to report more than 600 continuous spinal anesthetics without mortality or serious complication.

It should be emphasized that this technic is one of precision, requiring good equipment, carefully calculated pharmacologic dosage, and the important safeguards now routinely a part of the equipment in modern operating rooms. These safeguards include: available oxygen, vaso-pressor drugs, intravenous fluids, an understanding of the principles of gravity, auto-transfusion by which elevation of the lower extremities to right angles with long axis of the body promptly restores 700 to 400 cubic centimeters of the blood to the circulation.

Surgeons, obstetricians, and anesthetists, in approaching the study and use of this method, will soon find that prejudicial misconceptions concerning unwarranted complications reported and associated with this method will vanish before a scientific application and understanding of this advance in the conquest of pain.

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THE ROLE OF THE PATHOLOGIST IN SURGERY

Many surgeons themselves are good pathologists. While the converse may not be true to the same extent, the advice of the pathologist to the surgeon in many cases is indispensable. It is grossly inexcusable, and indeed poor surgery, for the surgeon to remove a uterus in which he is not sure of the nature of the lesion, particularly if the lesion is on the cervix. This is equally true in tumors of the breast or any other tumor from which a biopsy may be taken for study by the pathologist. Although the opinion of the pathologist may not be infallible, if the surgeon would seek his advice many radical and mutilating operations could be prevented. A simple diagnostic curettage may save many a uterus. Many an arm and leg have been removed for lesions that were perfectly benign. If a biopsy had been taken and submitted to the pathologist, the surgeon would have been saved a great deal of embarrassment and the patient a limb. No well trained surgeon today would attempt to operate without the pathologist "standing by." The operating room is the surgeon's work shop, however the surgeon and the pathologist should form a team of co-workers.

In this discussion reference is made to highly qualified pathologists only, since a poorly trained pathologist may cause the surgeon more grief in the sins of both omission and commission than if the surgeon had used his own judgment.

Because of the close relationship of the pathologist to the surgeon the Executive Council of The Southeastern Surgical Con-

gress during the Memphis Assembly in March decided to extend membership in The Congress to pathologists.

This decision was reached after the subject was presented to the Council by Doctor Gus Street of Vicksburg, Mississippi.

B. T. Beasley, M. D.

BOOK REVIEWS

The Editors of THE SOUTHERN SURGEON *will at all times welcome new books in the field of surgery and will acknowledge their receipt in these pages. The Editors do not, however, agree to review all books that have been submitted without solicitation.*

AGNOSIA, APRAXIA, APHASIA: THEIR VALUE IN CEREBRAL LOCALIZATION. By J. M. NEILSEN, B.S., M.D., F.A.C.P., Associate Clinical Professor of Medicine (Neurology), University of Southern California; Senior Attending Physician in Neurology, Assistant in Neuropathology, Los Angeles County Hospital, Los Angeles, California. With 59 illustrations. Second Edition, Revised. New York, 1946: Paul B. Hoeber, Inc.

This book is ambitious in plan but it fails in delivering. There are sufficient good observations to form the basis of an excellent short article; but these are so scattered in a mass of valueless material that it is doubtful that many readers will persist in the search.

After a brief historical introduction the author launches into a discussion of terminology and ends up by proposing 87 terms in which the clinical description is combined with the supposed anatomic location.

The first part of "The Evidence" is based largely on a review and classification of case reports in the literature, but including a small number of his own. This tends to confirm and, in some groups, to extend old concepts. Repeatedly he emphasizes his concept of a language formulation area and promises evidence to show that area 37 of Broadman in association with parts of 21 and 22 constitute a zone in which auditory, visual, and motor memories are synthetized to formulate concepts into finished language. But in his group of temporal lobectomies he presents a case in which speech was good, yet the entire temporal lobe including area 37, had been destroyed. In one (case R. R., page 111), the text states that area 37 was spared, yet the diagram clearly indicates that most of area 37 was removed. The others do not help to elucidate the significance of area 37. In the section of seven pages devoted to "The Language Formulation Area" he presents seven cases in all of which the lesion is confined to the parietal lobe, and, involving the supramarginal gyrus—area 37 is dismissed in one paragraph as follows:

> "Now concerning cases of isolated lesions in area 37 we find that such instances are difficult to find in vascular cases. But the type of case in which the symptom of amnesic aphasia occurs par excellence is otitic abscess of the temporal lobe. Such abscesses typically extend upward directly into area 37 from the middle ear. The large series of cases gathered by Henschen, by Blau, and Sonntag (1928), by Piquet (1931), and many personally observed leave no doubt on this score."

In the second part of "The Evidence," 33 personal cases are reviewed; but of these 15 are without autopsy findings, 4 were stuporous, deteriorated mentally, or psychotic, and in 10 lesions were numerous or very extensive. In 8 the correlation between clinical manifestations and autopsy findings is convincing.

It is interesting that the inability to visualize action as depicted in still pictures is in one (case S. E. H., page 188) attributed to lesions about the parieto-occipital sulci; whereas in another (case W. C., page 214) to destruction of the inferior surface of the occipital lobe.

There are many instances of totally irrelevant laboratory and physical findings presented in some detail. "Aber es muss eine gewisse Länge haben."

R. W.